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The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
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Reporting Progress

The war reaction on the foundry industry has stressed the diversity of its character. Thus, whilst steel, non-ferrous, malleable and the heavy sections of iron-founding are all busy, the light castings trade is short of work, although recently an improvement has been shown in certain lines. The Mines Department of the Board of Trade undoubtedly caused spasmodic disturbances by a premature order for the domestic rationing of electricity, coal gas and solid fuel. If this Order had been revoked *in toto*, then there would have been less grumbling, but there was an interval before coal and coke were placed in the same position as gas and electricity. This resulted in the merchants confining their orders to apparatus not burning solid fuel. The foundries which are probably the worst placed of all are those devoted exclusively to the manufacture of baths. Building, with the exception of military requirements, has virtually ceased, and reliance has now to be placed on the export trade. Whilst we do not pretend to know the ramifications of the armament requirements, it is difficult to envisage how the resources of such foundries could be used for the production of munitions. After the last war there was a boom in building, and we suggest that Government help might be sought in order that money might continue to be paid out in wages rather than in unemployment benefit.

Last week there was a question in the House which elicited a reply from the Minister of Supply that he had already received a deputation from the ironfoundry industry with the object of exploring the possibilities of replacing some types of steel castings by cast iron. Obviously, high-duty cast iron is implied, and fortunately through such organisations as the Research and Development Department of the Mond Nickel Company and the Copper Development Association, there is available a highly competent staff of metallurgists well capable of pioneering such work. It should be realised, however, that changes cannot be wrought overnight, and in extreme cases it will involve structural alterations to the melting plant, material modifications in sand preparation and a different moulding technique—that is, one more akin to steel practice. Moreover, a rigid compositional control is essential. If any of these factors be ignored, serious waste will result and the confidence now created amongst designers through prolonged and painstaking efforts will be undermined. Initially, there must be instituted, through co-operation, a full measure of control as the making of high-duty iron is not and never will be just a matter of simple alloying.

With the restitution last Sunday of Greenwich time, the difficulties of the foundries have been increased through the reduction of the daylight period in the afternoon. In this connection, it seems germane to refer to the talks now proceeding in the steel trade. Here it is being suggested that in order to increase production, a seven-day week should be worked. Some of the black-out difficulties could be minimised by this method in the foundry industry, though it introduces, especially with mechanised plants, the important question of week-end maintenance.

So far as the "intellectual" black-out is concerned, this has been largely dispersed and it is pleasing to record that well-attended meetings are being held all over the country. Most of the Branches of the Institute of British Foundrymen have held or are holding meetings, whilst the sections of the Institute of Vitreous Enamellers are making a beginning with a discussion on the Report of the Joint Technical Committee on a Recommended Method of Testing Acid-Resistant Enamels, supplemented by additional technical Papers. The Birmingham Section of the Institute of Metals, too, has arranged for a lecture later this month.

So far as "the Control" is concerned, this is working reasonably smoothly, and no difficulties are being experienced in obtaining an adequate supply of raw materials. Orders for ordinary business requirements are being executed much as usual, and the restrictions imposed are not onerous.

Iron and Steel Scrap Control

REVISED PRICE SCHEDULES

The Minister of Supply has made the Control of Iron and Steel (No. 5) (Scrap) Order, 1939, to take effect as from November 17, and fixing new prices for iron and steel scrap. The new Order applies to scrap iron and scrap steel and replaces the Control of Iron and Steel (No. 3) (Scrap) Order, 1939, which, with the Direction issued thereunder, ceases to have effect.

The general level of prices under the Order remains unchanged, but adjustments have been made in a number of cases where the prices originally fixed were found to create anomalies or to work inequitably. Provision is made in the Order for fixing maximum prices for any type of iron or steel scrap not covered by the Order, and also for fixing a special maximum price in cases where, by reason of transport or other difficulties, a consumer is not able to obtain adequate supplies within his usual area of supply at the controlled price. The main purpose of this last provision is to enable the consumer, when a shortage of scrap exists in his normal area of supply, to pay, in approved cases, the extra cost of transport of scrap from another area.

Maximum prices have now been fixed for scrap iron and steel used in the manufacture of refined pig-iron.

The Direction (No. 1) under the Order issued therewith repeats the provisions of the similar Direction under the previous Order, exempting the sale and purchase of scrap from the requirement of licence, except for certain special types.

Foundry Scrap

The maximum prices for scrap iron and steel for use for iron and steel foundry castings show numerous changes and a rearrangement of districts has been effected. There are important changes, also, in the general notes appended to the schedule. The quantity premiums previously listed, which ranged from 6d. extra for 50 tons and upwards to 2s. 6d. extra for 250 tons or more, have been withdrawn, and it is provided that 2s. 6d. per ton extra may be paid for quantities of 50 tons and over.

The revised schedule of prices for scrap iron and steel for use for iron and steel foundry castings is given in the accompanying table. Specifications are as follow:—

1.—*Short, heavy steel scrap*, consisting exclusively of rails, railway tyres and fishplates in 18-in. to 24-in. lengths (if scrap is required in less than 18-in. lengths an extra of 2s. 6d. per ton for cutting may be paid).

2.—*Short, heavy-steel scrap*, consisting of shearings, bar ends and constructional scrap not less than ½ in. thick and in 18-in. to 24-in. lengths (if scrap is required in less than 18-in. lengths an extra of 2s. 6d. for cutting may be paid).

3.—*Hematite ingot-mould scrap*, in cupola sizes.

4.—*Heavy machinery cast-iron scrap*, in cupola sizes.

5.—*Ordinary heavy cast-iron scrap*, not less than ½ in. thick, in cupola sizes.

6.—*Cast-iron railway chairs.*

7.—*Medium cast-iron scrap* consisting of gas stove plate, wringers and similar, in cupola sizes.

8.—*Light cast-iron scrap* in cupola sizes.

Following are the new general notes attached to the foundry scrap schedule:—

(*a*) The above prices are based upon the scrap being clean and to specification in accordance with the custom of the trade, otherwise a proper allowance must be made.

(*b*) The above prices are based on deliveries free to consumers' works; subject as mentioned in (*c*) and (*d*) below, other forms of delivery shall be in proper relation thereto.

(*c*) For sales c.i.f. ports or wharves on the East Coast of the United Kingdom the maximum prices shall be:—

(1) For ports or wharves on the East Coast of England—the above prices for consumers in Northumberland, Durham and Middlesbrough.

(2) For ports or wharves on the East Coast of Scotland—the above prices for consumers in Northumberland, Durham and Middlesbrough, plus 1s. per ton.

(*d*) For cast-iron scrap, specifications 4, 5, 6, 7, 8, arising in Scotland, for consumers in Scotland the maximum prices shall be:—

(*a*) For deliveries free on rail or free on lorry at loading point, the above prices for consumers in Scotland, less

(i) 3s. per ton and less

(ii) the excess (if any) of the actual cost of transport to consumers' works over 6s. per ton.

(*b*) For deliveries free to consumers' works, the above prices for consumers in Scotland, less 3s. per ton, but plus

(i) the actual cost of transport to consumers' works, or

(ii) 6s. per ton,

whichever shall be the less.

(*e*) Where delivery of scrap of any one specification under an order of 50 tons and upwards is tendered at the rate of not less than 50 tons per three months the above maximum prices shall be increased by 2s. 6d. per ton.

(*f*) All the above maximum prices shall be increased by 2½ per cent. in the case of sales by *bona fide* scrap iron and steel merchants carrying on business as such on September 22, 1939.

TABLE I.—*Maximum Prices per ton for Scrap Iron and Steel for Use for Iron and Steel Foundry Castings.*

For Consumers in	Specification No. 1	2	3	4	5	6	7	8
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Scotland	70 9	68 3	—	83 0	78 0	83 0	66 0	61 0
Northumberland, Durham and Middlesbrough	68 3	66 0	—	80 6	78 0	78 0	68 3	63 3
Cumberland	70 9	68 3	—	77 3	72 3	72 3	63 6	58 6
Westmorland, Lancashire and Wirral Peninsular	68 3	65 9	—	73 3	68 3	68 3	61 0	56 0
West and North Ridings of Yorkshire (excluding Middlesbrough)	73 3	70 9	107 3	75 9	70 9	70 9	66 0	61 0
East Riding of Yorkshire	73 3	70 9	—	79 3	77 0	78 0	66 0	61 0
Derbyshire and Nottinghamshire	73 3	70 9	107 3	78 3	75 9	75 9	68 0	63 0
Lincolnshire and Cambridgeshire	73 3	70 9	—	75 9	73 3	75 9	66 0	61 0
Cheshire(excludingWirral Peninsular)	66 0	63 6	—	75 3	70 3	70 3	60 6	56 0
Anglesey, Caernarvonshire, Denbighshire, Flintshire, Merionethshire, Montgomeryshire, Radnorshire	66 0	63 6	—	73 3	68 3	68 3	58 6	53 9
Shropshire, Staffordshire, Worcestershire and Warwickshire	68 3	63 6	100 0	81 0	76 3	76 3	69 0	64 0
Leicestershire, Northamptonshire, Huntingdonshire and Rutland	70 9	68 3	—	78 6	73 9	76 0	64 0	61 0
Norfolk	70 9	68 3	—	75 9	70 9	75 9	61 0	56 3
Suffolk	70 9	68 3	—	76 9	71 9	76 9	63 3	58 6
Cardigan, Brecknock, Carmarthen, Pembroke, Glamorgan, Monmouth, Hereford and Gloucester	70 9	68 3	—	75 9	70 9	75 9	67 0	62 3
Somerset, Dorset, Wilts, Hampshire and Sussex	66 0	63 6	—	75 9	70 9	70 9	61 0	56 3
Oxford, Berks and Beds	66 0	63 6	—	78 0	73 3	73 3	66 0	61 0
Essex and Kent	66 0	63 6	—	78 0	73 3	73 3	64 6	59 6
County of London	66 0	63 6	—	73 3	68 3	68 3	61 0	56 3
Middlesex, Surrey, Herts and Bucks	70 9	68 3	—	75 9	70 9	70 9	63 6	58 6
Cornwall and Devon	66 0	63 6	—	66 0	61 0	—	51 3	46 6
Northern Ireland	—	—	—	75 6	70 9	—	58 6	53 6

Calculation of Scottish Prices

An explanatory memorandum issued by the British Iron and Steel Federation states that the formula for the calculation of the maximum prices of cast-iron scrap arising in Scotland, for foundries in Scotland, should be applied as set out in the following examples:—

Example No. 1.

The maximum prices per ton, for a consumer in Scotland, of cast-iron scrap, specification No. 4, arising in Scotland, delivered *free on rail at loading point*. The transport costs are 10s. per ton.

	s. d.	s. d.
Price shown in schedule for consumers in Scotland		83 0
Less—		
3s. (Note (*d*) (*a*) (i))	3 0	
The excess (if any) of the transport costs of 10s. per ton over 6s. per ton (Note (*d*) (*a*) (ii)	4 0	7 0
Maximum price		76 0

Example No. 2.

The maximum price per ton, for a consumer in Scotland, of cast-iron scrap, specification No. 4, arising in Scotland, delivered *free to consumer's works*. The transport costs are 10s. per ton.

	s. d.
Price shown in schedule for consumers in Scotland	83 0
Less—	
3s. (Note (*d*) (*b*) (i))	3 0
	80 0
Plus—	
6s. (As the transport costs exceed 6s. per ton the addition is restricted to 6s. per ton—Note (*d*) (*b*) (ii))	6 0
Maximum price	86 0

Dunswart Iron and Steel Works

At the annual meeting of the Dunswart Iron & Steel Works, Limited, held on October 25, in Johannesburg, MR. J. K. EATON (chairman) said that the additions to the electrical and mechanical equipment of the electric steel-melting furnaces were all completed during the year under review and these additions had made possible increased tonnages of molten steel. In view of possible further demands in steel products, further plant additions would become necessary during the coming year and this work was in hand.

More than adequate demands were experienced for their rolling mill products, although at the beginning of the year there was a falling off in demand for steel castings, probably due to the unsettled European situation. The increased tonnages of rolling mill products were therefore offset to a certain extent by the smaller tonnages of castings produced. At present there was a considerable demand for steel castings which could be met by equipment available at the works.

The price of rolling mill products was reduced during last October in agreement with other South African iron and steel producers. This reduction affected profits and had offset the advantage obtained by the reduced costs of production due to the more efficient operation of plant. The price obtained for castings remained approximately the same as that obtained during the previous year.

Running Thin Castings

METHODS FOR POURING ON END AND ON THE FLAT

A useful contribution has been made to literature dealing with the running of castings by GUY HENON in an article which has appeared in recent issues of "La Fonte." Because of their widespread use and undoubted interest, the following translation has been made of his remarks relating to the running of thin-sectioned castings.

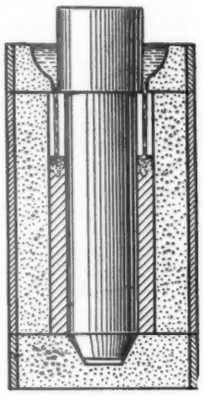

FIG. 1.

Casting on End

Taking the case of a thin hollow casting, such as is shown in Fig. 1, it is usually deemed necessary to have a slow filling runner, because of the height, and because of the small volume to be filled, whilst, of course, maintaining a well liquid free surface. Very often, however, the minimum requirements ought to be largely exceeded, for the slow running can bring out a dangerous degree of hardness in the metal. In many cases direct running is practised, and

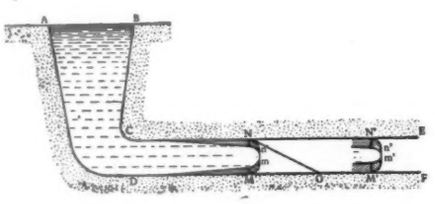

FIG. 4.

Fig. 1 shows an example. Such castings as iron pipes, cylinder linings and segment crowns are successfully cast by this method.

Running should be quicker when the metal has to cover a part forming a core, as shown in Fig. 2. A cold metal is liable to give cold shuts and blowholes. Often in the case of cast-iron baths or basins one or several runner bushes are arranged for, the metal entering the mould cavity by a thin circular aperture or by a number of circular holes. Fig. 3 shows a layout for casting a bath, cut at right angles through the runner bush.

It seems wise to stress that with moulds cast directly downward, the evacuation of the mould gases is more difficult than when bottom poured. Hence the necessity to provide for risers, vents and particularly to insist upon ample permeability in the sand used.

Casting on the Flat

This method is widely used in connection with the moulding of stove grates and ranges. When casting thin sections, the cardinal point is to ensure a sufficiently quick filling so as to avoid cold shuts and short runs. Usually the thickness of the gates is small, for they should be less than the thickness of the casting. Yet it is not always possible to make them of any great length. Put another way, for any given section of gate, it is necessary to have a maximum delivery, and one giving a pressure is the only feasible solution.

Several lessons can be drawn from a theoretical examination of the progress of liquid metal through a restricted passage. In Fig. 4 a runner ABCD feeds a restricted opening CEDF, shown in a highly exaggerated manner so as to make the sketch clearer. If the metal is perfectly fluid at any given moment, its free surface in the channel would be an inclined plane, as is indicated by the line NO. Actually it forms a skin—a truly elastic sheath which prevents the development of the inclined plane. The extremity of the stream takes the form of a meniscus M*m* and N*n*. Under the cooling action of the mould the edges of the meniscus M*m* and N*n* are in course of solidification, but are not rigid, for they come up against the walls progressively with the movement of the stream. There they form a solid skin. The nose *mn* of the meniscus has every appearance of being made up of the skin referred to above. It is constantly being torn at its centre, thrown towards the edges and replaced by the skin of new liquid metal reaching the extremity of the stream.

Normally, the metal stops when the thickness of the solid sheath is very pronounced, as is shown at M′N′, for instance. The edges M′*m*′ and N′*n*′, because of their rigidity, can no longer spread themselves out. The skin *m*′*n*′ thickens up and resists the power of the metal of the central part, which, itself markedly cooled, loses its fluidity.

If there should be a stoppage during pouring, the stream is momentarily immobilised at MN, the meniscus is submitted to an intense cooling by the walls. It solidifies practically instantaneously and forms a "cork" which often prevents further progress of the metal.

This shows that in the casting of thin castings, it is insufficient to provide a fairly high average input. It is also necessary to avoid any "resting" of the metal, not even for an instant, as there is always a risk of premature solidification. Fig. 5 shows a plate ABCD cast horizontally. The metal enters by the gates AE and DF, which, in certain conditions, cannot be prolonged towards the centre. The metal successively fills the zones bounded by the curves I, II, III and IV. After curve I the metal has a tendency to flow towards the centre more than straight in front. The low rate of progress of the front edge may bring about premature solidification, and the casting shows either cold shuts or a short run. It is usual to overcome this drawback by slightly tilting the mould, as shown in Fig. 6. The metal leaving the gates immediately spreads itself along the length of the mould cavity, and continues to fill the mould without "resting" at any point.

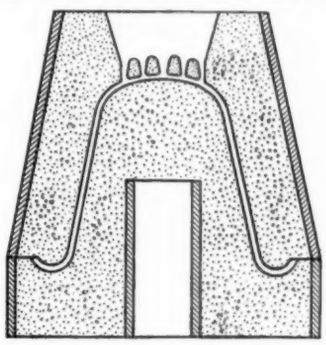

FIG. 2.

FIG. 3.

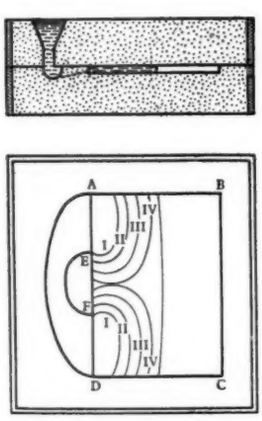

FIG. 5.

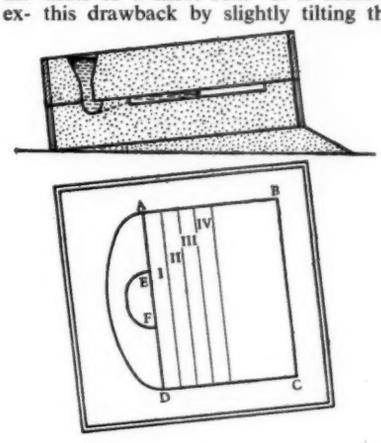

FIG. 6.

Council of Industry

The representatives of the Confederation of Employers on the Council of Industry, composed of representatives of employers and employed, and appointed to advise the Government on the management and control of wartime production and supply and the handling of labour problems, include:—Mr. W. A. Lee (mining), Mr. Lewis Jones, M.P. (iron and steel), Mr. J. S. Boyd (shipbuilders), Mr. G. L. Derbyshire (railways), Mr. S. S. Ogilvie (gas industry), Sir Alex Ramsay (engineers), Mr. R. Sneddon (shipping), and Sir J. Walker Smith (building trade).

D

Founders' Forum

Economic Use of Non-Ferrous Scrap

Q.—What differences exist between "tough pitch" copper and oxygen-free copper?

A.—The term "tough pitch" applies to virgin copper which has been remelted during manufacture, and is available primarily in the form of "high-conductivity" material, such as "electro-copper" and "H.C. fire-refined," and secondly in the form of "mechanical coppers," of which "best selected" is a typical example. Tough-pitch coppers are all useful for foundry purposes, but it can be expected that the ease in obtaining sound castings will bear a relation to the oxide content of the copper. Over 80 per cent. of the world coppers produced to-day are electro-refined, the bulk of which is "tough pitch." They are amongst the purest available and average 0.02 to 0.04 per cent. of oxygen. This latter figure is somewhat below the minimum oxide content required to counteract the effects of hydrogen, but this can be increased to a satisfactory degree by simply remelting under oxidising conditions.

Oxygen-free copper such as "cathodes," an electrolytic form which has not been changed into the tough-pitch state by remelting, must be very carefully handled in the foundry. It contains appreciable quantities of hydrogen, and in the absence of oxide is liable to give erratic results. Melting under oxidising conditions alone may not provide enough oxygen to meet requirements, but satisfactory results can always be obtained by the addition of cupric or cuprous oxide during melting. Other oxygen-free brands of the "deoxidised" or "O.F.H.C." type which have been remelted at some stage of their manufacture, whilst not containing oxides, neither contain hydrogen, so the oxidising treatment in the foundry, whilst being necessary, need not be so drastic as for "cathode" copper.

Q.—What forms of copper scrap may be used in the foundry?

A.—Firebox, cable and tube scrap can all be safely utilised for foundry service. Firebox is particularly good, inasmuch as it has a high oxygen content (0.08 to 0.1 per cent.), and an additional oxide surface coating which limits gas pick-up during melting. Furthermore, the section is fairly heavy, which assists handling, etc. The arsenic content in this material does not seem to cause trouble, at least in gunmetal and bronze, as some founders believe. Cable and tube scrap are both useful foundry materials. They invariably contain enough oxide either in the metal or on the surface to satisfy foundry needs, whilst the large surface area in relation to weight assists in further oxygen pick-up with suitable furnace practice. This latter factor is a disadvantage in one respect, namely, that both cable and tube scrap are awkward to handle and necessitate baling or cutting into lengths and flattening before they can be employed for crucible melting.

Q.—Which produces the better gunmetal and bronze castings, virgin metal or scrap?

A.—Many foundrymen believe that secondary or scrap metal produces better castings than new metal, and to a certain extent past experience has proved this to be true. All secondary material such as gunmetal ingots or scrap invariably contains a higher oxygen content than new metal, and this tends to prevent gas absorption and promotes density with consequent increase in mechanical properties and casting quality. It is important to note that the oxygen must be present as copper oxide, but this condition is not difficult to obtain as this is usually the principal oxide formed in the melting of copper-base scrap materials. The degree of formation will depend upon the condition of the secondary metal, *i.e.*, light and returned foundry scrap will produce higher oxide contents than heavier materials such as ingots. Melting conditions will also naturally have an important bearing on the matter, and oxidising atmospheres should always be employed. It should, however, be emphasised that with the adoption of the latest melting technique, embracing controlled oxidation by furnace atmosphere and direct oxide additions, the quality of castings produced from virgin or secondary metal should be identical.

Q.—How will restricted metal supply affect economy?

A.—With restrictions on the use of new metals, the scrap question should be given serious consideration by all foundrymen and an attempt made to utilise economically all available material, either foreign or domestic, as far as possible. The best results in this direction will materialise from those foundries possessing a laboratory and metal reclamation plant. Small brassfounders should not attempt to utilise outside scrap supplies unless composition can be guaranteed, and are advised to obtain secondary metal requirements from recognised ingot producers where efficient cleaning facilities are available for the production of material to analysis. Larger concerns, particularly those making valve, plumbing and similar castings in gunmetal containing 5 to 8 per cent. tin, 2 to 5 per cent. zinc, 2 to 5 per cent. lead, yellow brass, etc., can safely commit themselves to the purchase of outside scrap. Purchases should be made to a rough specification, and this should be checked by analysis as soon as possible after receipt of a consignment.

Q.—How can bulk purchases and domestic scrap be controlled?

A.—A very satisfactory method for obtaining a representative analysis is to select, say, 300 lbs. of typical sections from every 5 tons of scrap after it has been passed over the magnetic separator, to melt it, cast into ingots, and combine drillings from the first and last ingot for analysis. The result obtained can be employed as a basis for making subsequent charges for direct casting, keeping in mind that aluminium is about the only element likely to cause trouble in pressure work. In regard to domestic scrap, the collection of miscellaneous skimmings, floor sweepings, riddlings from sand, etc., should be carefully practised and remelted, pigged and analysed from time to time. Some contamination may arise in this direction from aluminium in the case of foundries making light alloys as well as bronze, should care not be taken to keep the former segregated. Slight admixture of unalloyed particles of aluminium with bronze or brass riddlings, swarf, etc., can be counteracted to some degree by the addition of 1 per cent. barium peroxide to the charge when melting down. This enables oxygen to be evolved at low temperatures, which oxidises the particles of aluminium to alumina and so prevents combustion with the balance of the metal.

Q.—What precautions are necessary when melting swarf?

A.—In the crucible melting of swarf, care should be taken not to overdo the oxidation treatment, otherwise high metal losses will be experienced. Under normal oxidising melting conditions scrap of this nature picks up more oxygen than is actually required, and this should be controlled by careful furnace atmosphere adjustment. Prevention of excessive oxidation can also be brought about by mixing the swarf for charging with 0.5 to 1.0 per cent. of granular soda ash.

Q.—How should aluminium-bronze scrap be dealt with?

A.—Aluminium-bronze scrap is a very awkward metal for remelting purposes, but it should be noted that this material provides a very useful base for the manufacture of addition alloys such as ferro-copper, manganese-copper, etc., required for the production of manganese-bronze and other high-tensile brasses. The presence of aluminium facilitates solution of pure iron and manganese in copper.

Q.—Does a zinc addition to bronze facilitate the production of sound castings?

A.—The presence of zinc is a great asset in the founding of bronze as the chance of producing unsound and porous castings is less than if a zinc-free alloy is specified. The well-known bronze containing 88 per cent. copper, 10 per cent. tin, 2 per cent. zinc was developed, it is thought, because of the difficulty encountered in casting the pure tin bronze originally chosen for high-class steam and water fittings having the composition 90 per cent. copper, 10 per cent. tin. This latter alloy is still demanded "zinc-free" by some engineers where maximum resistance to corrosion is required. Phosphor and gear bronzes are further modifications of the 90/10 alloy in which the presence of zinc is looked upon with suspicion. So far as can be seen there is no evidence whatsoever that small amounts of zinc around 0.5 per cent. have any noticeable effect on wearing properties or on resistance to corrosion. Suggestions have been made that traces of zinc have a deleterious effect on bearing or gear bronzes, because it hardens the alpha phase, thus lessening the differential hardness between this and the alpha-delta eutectoid. In engineering practice, however, this has never been susbtantiated, and it is considered improbable that less than 1 per cent. of zinc is likely to affect properties in service. Similarly, in the production of the zinc-free acid-resisting bronzes, soundness in the casting is as important as composition in obtaining adequate corrosion resistance, and in view of the beneficial effects of zinc in this direction it is always advisable to include up to 0.5 per cent. Founders should, wherever possible, bring these points to the notice of engineers with the view of getting specifications amended as the zinc-free 90/10 base alloys are at present a prolific source of trouble in the foundry so far as sand castings are concerned. It should be noted, however, that the foregoing remarks do not necessarily apply to chill-cast or centrifugally-cast articles.

Catalogues Received

Core-Shop Equipment. We have received from Harry F. Coggon & Company, of 49, Savile Park Road, Halifax, Yorks, a six-page folder, which illustrates some Rocket core-making installations and their products, as well as giving a diagrammatic sketch of a continuous core-drying stove. With the folder were enclosed several blotters carrying illustrations of foundry plant on the reverse side.

A.R.P. Air-Bricks. Richardson, Tuer & Company, Limited, of Hope Foundry, Farnworth, near Bolton, have received provisional patent protection for a line of air-bricks which they are manufacturing. This new air-brick carries a recessed hinged external cover, the recess being filled with weatherproof packing so as to form a gas-proof joint. The opening or closing of the covers is but a matter of seconds, and well answers for those existing just above ground level, whilst those situated higher up can, if necessary, be operated from the inside. The system has been extended to take in the cases of the outlets from domestic gas appliances. Part of the object of the folder is to advise architects to incorporate poison-gas-proof air-bricks in all projected buildings. The system is being used by H.M. Office of Works for vital control centres.

The Charcoal-Iron Industry*

By H. GWYNN JONES, M.A.

Of the English iron industry it has been said that "from the middle of the eighteenth century there are clear indications that . . . (it) had entered upon a period of decline . . . When the eighteenth century opened, the English iron industry in all parts afforded a striking illustration of what the modern economist knows as "decreasing returns."[1] This darkest hour was before the grey dawn of the Industrial Revolution, that revolution which gave to the iron industry of this country a century of world leadership. It was the decline in the eighteenth century which produced necessity, and necessity begat invention, so that while the iron industry was dying men were seeking a remedy, and this remedy when discovered not only cured the patient but also changed him into a giant. The disease had been scarcity of charcoal; the remedy was coal. The story of the decline of the iron industry was a story of decreasing supplies of charcoal, and charcoal was then essential in the smelting of iron; the story of the industry's revival is the story of success in discovering a substitute for charcoal.

The history of iron smelting has had three main phases—that of the direct process; of the indirect process using charcoal; and lastly, of the indirect process using coal. The direct process consisted in the conversion of iron ore into wrought iron under one roof, and more or less without a break; charcoal was the fuel used in this process and the most obvious and most general example of its use was to be found in the Catalan method, whereby the ore was smelted into a mass of iron which was then worked into wrought iron ready to be converted into various articles. The adoption of the indirect method, using charcoal, followed this and was in itself a revolution bearing the germ of the Industrial Revolution inasmuch as it foreshadowed both extensive division of labour and its brother mass-production, but the reasons for its adoption were not confined to those commonly associated with either division of labour or mass-production; indeed, one of the fundamental reasons for adopting the process may well have been the scarcity of charcoal. Before proceeding to a discussion of the scarcity of charcoal as a possible reason for the change it will be well and interesting briefly to describe this means of producing iron—a means introduced somewhere about the beginning of the sixteenth century.

Early Method of Production

The ore was first burnt—or "calcined"—with charcoal, wood, or coal and thus broken into small pieces; meanwhile the furnace—a stone structure shaped like a cone with the top sawn off—was being heated—"seasoned"—with charcoal burning slowly. When both ore and furnace had been thus prepared, smelting began; the ore was thrown, alternately with charcoal, into the furnace and the "blast" put on by means of two large bellows worked by water-wheel and blowing alternately. In about three days' time, if all went well, the metal began to "run" through the "timp" into a bed of sand furrowed herring-bone fashion, the amount increasing daily and reaching the maximum after about a fortnight; when slightly less than red-hot the metal was broken, first into "sow" and "pigs"—the "sow" being the central furrow, and the "pigs" the offshoots—and then the "sow" was broken into equal lengths with the "pigs"; the term "pig-iron" is derived from a comparison of the central furrow and the offshoots to a sow feeding her litter. With the breaking of the metal into "pigs" the furnace process ended[2] and the pig-iron was ready for refining and to this end it was taken to the forge. The forge had two main departments—the "Finery" and the "Chafery"—both of them under one roof and consisting of two open hearths upon which were large heaps of burning charcoal kept at a high temperature by a "blast." In the "Finery" the pig-iron was melted down "as thin as lead" and then allowed to thicken gradually into a lump called a "loop."[3] The "loop" was then put under a hammer—worked, like the bellows, by a water-wheel—and beaten into a thick square called a "half-bloom"; the half-bloom was placed again in the "Finery" for an hour and then returned to the hammer which this time beat it into a "bloom"—a square bar with square knobs at each end. The iron was now ready for the "Chafery" where it was beaten out into bars of convenient commercial shapes and sizes and ready, if needed, to be taken to a slitting mill, where it could be drawn out or cut into rods.[4]

As has been stated, this was an advance on the direct method and one writer has remarked that "in the broadest sense, the transformation of the (iron) industry was a substitution of indirect processes for direct processes."[5] The usual primary condition for division of labour is an extended market but in the case of the pre-Industrial Revolution iron industry in this country, the scarcity of charcoal was also a primary factor. By the time of Elizabeth the demand for charcoal caused by the iron industry had made such inroads into the supply of timber—needed for the navy—that acts against deforestation in this manner had to be passed.

Factors Governing Choice of Site

As the supply of charcoal continued to decrease the iron industry was not only driven from old geographic positions but also forced to split. There was one obvious reason for splitting—in those days of difficult transport the immediate neighbourhood was very important for supplies of raw materials; a furnace and a forge in the same district would create a double demand on the same source of supply and, consequently, it became necessary to place the furnace's complementary forge in a locality where it would not draw on the furnace's charcoal supply, and so both furnace and forge would each have its own separate supply and the radius of its circle of demand would be shortened; consequently transport costs would be decreased.

From this arrangement arose a further difficulty—the transport of pig-iron from furnace to forge. Land transport was sometimes impossible and always difficult and expensive, hence both furnace and forge would have to be placed near the sea, a navigable river, or a canal. Yet another problem had to be considered—the supply of water-power in the form of rapid-flowing streams. The river, suitable for transport purposes, would not be fit for power and *vice versa*; hence a rapid stream with a plentiful supply of water and near a navigable river or the sea was essential. In addition the site should be near to supplies of iron ore. The requirements of an ironworks were therefore: (*a*) A supply of wood for charcoal; (*b*) a supply of iron ore in the case of the furnace; (*c*) transport facilities, usually water-transport, to connect furnace and forge, and forge and market, as well as similar facilities for transport of raw materials; and (*d*) swift-flowing streams for power.

The consequence was that ironworks were erected in what would to-day be regarded as the most unlikely places for industry—the Shropshire iron industry, for example, migrated in part to the mountain valleys of North Wales and places so remote as Dolgelly, in Merionethshire, Dolobran, in Montgomeryshire, and Glan Fred, in Cardiganshire, became for some time the homes of iron production. This was indeed a wandering in the wilderness on the way to the Promised Land.

The scarcity of charcoal was evidently wide in its influence on the iron industry; it is certain that it played some part in the adoption of the indirect process; it obviously put ironmasters at a disadvantage *vis-à-vis* the controllers of charcoal; by increasing costs it increased prices and so curtailed sales and consequently production. In these ways it paved the way for the Industrial Revolution; furthermore, by driving adventurous souls in search of a substitute which would be cheaper and less exhaustible than charcoal, this scarcity created pioneers of the Industrial Revolution.

Coal Replacing Charcoal

The search for a substitute began before the eighteenth century. In the early seventeenth century Simon Sturtevant tried and failed; in 1613 John Rovenzon applied for a patent but failed to apply his ideas in practice; then in 1620 Dud Dudley persuaded his father, Lord Dudley, to take out a patent "for melting iron-ore, making bar-iron, etc., with coal, in furnaces, with bellows." Dudley, as far as one can judge, was not unsuccessful but he had to contend with both nature and man, for his works were destroyed by flood, and he had always to suffer the jealousy of rival ironmasters who combined against him; Dudley was overwhelmed with debts but re-started, and in 1655 was smelting iron with coal; in 1684 he died and his invention perished with him. Dudley, having no direct successor, did not stand at the beginning of a continuous movement and in that sense cannot be called a pioneer, but he had made the attempt and the memory of the rumour of his having had some success must have encouraged others who were to follow.

Among those who followed—and the most prominent among them—were the Darbys of Coalbrookdale. It has been said that a Darby used coal for smelting iron in the early years of the eighteenth century; this is unlikely, but by 1709 he had already "established coke-smelting of iron on a commercial scale."[6] Coke was itself a comparatively new product, for the first patent was taken out in 1627; it was devoid of some of the impurities of coal, was less inflammable and, consequently, it was a simpler substitute, but Darby seems to have been the first to use it and even then only to produce castings, for which it was better suited than was charcoal; to make pig-iron destined for conversion into wrought-iron he, also, used charcoal. It was left to the Coalbrookdale works eventually to discover a method of using coal in all the processes of smelting, but when this happened and who was responsible are questions which have not been satisfactorily answered—it may have been by Darby in 1735,[7] or by Richard Ford who managed the Coalbrookdale works in 1747. Whatever the date may be the effect of the discovery did not make itself felt for a long time, for even after 1760 iron was produced mainly with charcoal.

The eventual success of the Coalbrookdale works has overshadowed other attempts at discovering a substitute, but others did make the attempt and not all of them with coal. There is some interesting correspondence between the Society of Arts and a "George Jones" of Rhosgellan in the Society's MSS.; Jones actually claimed that he had seen charred turf used instead of charcoal for smelting in Ireland; he does not give many details but the Society gave him a very sympathetic answer[8]; it is possible that Jones may have seen charred turf used in

* Paper read before the Royal Society of Arts on November 15, Mr. E. F. Armstrong, Ph.D., D.Sc., F.R.S., presiding.

the "calcining" process, although his interest in metallurgy—judging by his many letters on the subject—appears to render his making such a mistake unlikely. Yet another who experimented with a substitute was William Wood—of Irish half-pence fame; he made the attempt both with coal and coke dust. Wood in turn was connected—commercially—with another, Charles Lloyd of Dolobran. Lloyd was a member of a Quaker family which was intimately connected with the iron industry in the eighteenth century and one of whom founded Lloyds Bank. He had an iron furnace at Bersham near Wrexham, and an iron forge by Dolobran, Montgomeryshire—the Bersham works was later to become famous under John Wilkinson, who was probably a member of the Royal Society of Arts.

Coke for "Potting"

Perhaps under the influence of his fellow Quakers, the Darbys, Lloyd made serious attempts in smelting with coal; in 1720 he changed from charcoal to coke for "potting" (making castings, usually iron pots, hence the term), and was probably successful, for he was sufficiently encouraged to decide to change over entirely to coal-smelting in 1726. This second step was a failure, for Lloyd soon appeared before the court for bankruptcy; the failure, however, need not of necessity have been technical; it may have been commercial and financial—coal-melted pig-iron was an innovation still and what previous reports there were of it were not favourable; therefore, it could not gain the confidence of the market very quickly. Lloyd's enterprise was, like most mining enterprises in North Wales at the time, probably under-capitalised, and in consequence he could not afford to wait long for the returns.

Advice from Wilkinson

It is natural to ask what was the attitude of the Society of Arts to this question of discovering a substitute for charcoal. Most of the attempts mentioned were made before the Society was born so that, naturally enough, the Society could have had no attitude towards *them*; after being born, however, and very soon after being born, the Society interested itself in the question, for it is seen that it was corresponding with J. (or "I") Wilkinson about it. This Wilkinson may not have been the Bersham Wilkinson, but considering the latter's knowledge of the iron industry and having regard for the fact that the Society had directed its questions to him it seems more than probable that this was "the" Wilkinson. He writes—in 1761, or not long afterwards (the letter is undated)—an "answer to (the) Q(uestio)n concerning Barr iron" and proceeds—"in order to give proper encouragement for the making of bar-iron with pit-coal, it may be worthy (of) the Society's notice to consider how the following improvements may be useful and what may contribute most thereto—

First:—

The making of pig-iron equally as good as that made with wood charcoal and which may be sold on (the) same terms—

The proof of this to depend on the majority of Forge Iron-masters whose principal business is to make bar-iron from the pig.

Secondly:—

The making of tough bar-iron from coke pigs (*i.e.*, pig-iron smelted with coke) equal in goodness to that made from pigs smelted by wood charcoal—

The proof of this will depend upon the different manufacturers.

Thirdly:—

The making of bars from coke-pigs that will convert into steel equal in goodness to that which is made from Swedis(h) bar-iron and sold under the denomination of Common Blistered Steel—

The proof of which will depend upon the Edge-tool makers.

Remarks:

This kingdom has materials enough to make all the iron that is consumed provided the Coke scheme can be established in the making of pig-iron equal in goodness to those made with charcoal; and though it is a doubt whether the coke can be introduced in the second operation (or that of making it into bar-iron from the pig) yet if we can succeed in the first operation with coke we shall then have wood sufficient for the forge-master to make all the iron that might be wanted.

It takes more wood charcoal to make one ton of pig-iron than to refine a ton of bar, and the allowance being four tons of pig-iron to make three tons of bar-iron, it follows that about double the quantity of wood charcoal is consumed to that which is used in the forge, and that if the first operation could be established with pit coal there would be cord-wood enough in Great Britain to refine from the pig all the bar-iron that is sold in this kingdom.

I presume there would be no great difficulty in procuring from the Custom House the quantity of iron imported from Russia and Sweden for the year 1761 into the Port of London; add to this a supposed quantity for Bristol, Liverpool, Hull and other out ports and, when it is considered that the chief part of said iron is paid for by bills of exchange, the balance against England will appear an affair worthy (of) the most serious attention of the Society; more especially as Nature has been so kind as to furnish us in this kingdom with a fund of materials almost inexhaustible provided the pit-coal scheme can be established.

For my own part, I think it is very probable that great improvements will be made in the course of a few years, and that nothing would contribute more to its advancement than encouragement from your Society."

This can well be considered a most important document for it reveals on authoritative evidence that even after 1761 the iron industry was generally tied to charcoal; it also corroborates what has been said of coal as a means of smelting iron, particularly pig-iron—that its fault was in the failure to convert coal-smelted pig-iron into good bar-iron, not to mention into steel. Wilkinson's remarks foreshadow the immense change in industrial status that Great Britain was to experience when iron and coal were finally wedded, but even he dared not guess that charcoal could be completely eliminated nor that this country should lead the world industrially for at least a century. The document is also a tribute to the Society of Arts inasmuch as it shows how the Society so very early after its birth interested itself in a movement which was to have such immense results and which was to change the political, social, and economic structure, first of Britain and then of Europe.

The final success in smelting iron with coal changed the industry; decentralisation gave way to centralisation, the scattered homes of the industry were drawn together to localities where coal and iron ore were found side by side, and they were so found so often that it could well be thought that Nature herself had intended the wedding. With the discovery of steam power—again dependent for its application on coal and iron—industrial Britain began to emerge, coal began to stamp its character on the land and industry became synonymous with grime, blackness and over-crowding; the charcoal-iron industry had a touch of the rural in its setting and, often, in its ownership; the old furnace and forge had produced according to demand; the industry had been bound by geographical conditions to an extreme extent. When coal displaced charcoal, and when steam took the place of water-wheels, the industry ceased to be bound by the necessity for a wooded district with rapid streams, leaving only the necessity for a coal-field with iron ore and transport facilities—a small difference in theory but in practice a great one—and the last demand was to be a factor leading to the creation of canals and turnpike roads.

[1] Ashton, "Iron and Steel in the Industrial Revolution."
[2] Furnaces also produced "castings," i.e., cast-iron articles. Abraham Darby, in the early eighteenth century, discovered a means of running the molten iron directly into moulds; iron pots were generally made thus.
[3] There is a vulgarism in South Wales—"knocking him into a loop"—which may be derived from this.
[4] The description is based on Plot: "Natural History of Staffordshire" (Victoria County Histories).
[5] Usher: "An Introduction to the Industrial History of England."
[6] Ashton, *op. cit.*
[7] Percy: "Metallurgy: Iron and Steel."
[8] See "Guard Book" 1, 29, 34, 55, 56; iii, 16; "Historical Register, Transactions II," for the correspondence. "G.B.," I. 56 is the letter concerning charred turf, while "Hist. Reg. Trans. II" is the Society's answer.

Wartime Factory Lighting

NEED FOR EFFICIENT BLACK-OUT

The return this week to G.M.T. has not been welcomed by those works which are still trying to carry on production with "make-shift" black-out methods. Satisfactory black-out methods must be adopted and should be of a permanent nature. If the output of the factory is to be maintained, good seeing conditions must be retained during working hours. For those factories engaged on work of national importance it is of vital necessity that quantity and quality of output should be increased. Some firms have found that during the black-out arrangements, artificial light becomes necessary earlier in the day, and in factories where inadequate seeing conditions prevail, production shows a further reduction. This may well be the case when factories have to convert other parts of the building for precision work, and the lighting installation is only suitable for rough or medium work. Such instances should receive immediate attention and sufficient light provided.

High-intensity lighting is necessary for precision work and often calls for special lighting. The trough-type fitting provides a high level of diffused light superior to the ordinary method of local lighting. Benches near the walls can be illuminated to a high level by means of light projected on to the walls. Both these methods provide an excellent diffused light, particularly suited to inspection of highly-polished parts, for the reading of scales or the assembly of small parts. To illuminate large areas with good diffused lighting, a mixed lighting unit comprising mercury discharge and tungsten lamps enclosed in an industrial diffusing reflector gives a good degree of colour correction, and provides a greater light output for the same wattage of tungsten lamps. Whatever form of local lighting is used it should only be supplementary to the general overhead lighting, and the ratio should not be greater than 10 to 1, and, if economically possible, it will be found better to keep within a 5 to 1 ratio.

Maintaining an effective black-out for doorways and ventilators often creates difficulties which can only be overcome by the construction of light-traps or light-locks. It is essential in a large factory that light-locks at main exits should be as simple as possible to allow quick and easy transit. The most simple method is to build a wall opposite the exit at least 5 times the width of the opening, roofed at not less than 7 ft. The walls, roof and floor should be painted black, so that all the light will be absorbed. For hand trucks that have to be wheeled from one building to another, a light-trap fitted with swing doors at both ends offers a satisfactory solution, as the truck can push the first doors open, and providing a reasonable space is allowed before reaching the outer doors, the first set will have automatically closed. A similar device, but with hand-operated doors, can be used for lorries when they have to enter a building for loading or unloading.

Increasing the Industry's Efficiency

Mr. NORMAN ERSKINE'S PRESIDENTIAL ADDRESS TO FOUNDRYMEN IN GLASGOW

The large attendance at the opening meeting of the Scottish Branch of the Institute of British Foundrymen, held in the Royal Technical College, Glasgow, was favourably commented upon by MR. ROBERT BALLANTINE (the retiring President), who occupied the chair. The Branch Council, he said, had given very careful thought to the matter of holding meetings, and had come to the conclusion that it would be to the advantage of the members to carry on as far as possible. It might be found necessary to modify the programme which had been arranged, but he hoped that the usual number of meetings would be possible.

Mr. Ballantine thanked the Council and members for the assistance and support which had been accorded to him during his term of office, and for the manner in which they had borne with him through the difficult time he had had due to ill-health. Introducing his successor, Mr. Norman Erskine, the speaker asked for Mr. Erskine the same support as he himself had received. Mr. Erskine, as member of Council and as Vice-President of the Branch, had been unfailing in the execution of his duties, and no more worthy choice of a President could be made.

MR. N. ERSKINE, in thanking the members for having elected him, said that with the assistance of the Council and full support of the members he hoped to maintain the traditions of the Scottish Branch. Mr. Ballantine had now joined the ranks of Past-Presidents, and no doubt he would continue his interest in the work of the Institute. The members were very glad that he had recovered from his serious illness and they wished him the best of health in the future. They were very thankful for the work he had done and the manner in which he had carried out his duties.

During the period of Mr. Ballantine's Presidency there had been an increase in membership, a series of good Papers and the Post-Congress tour of the delegates attending the World Foundry Conference. Mr. Ballantine had done much useful work in connection with the visit of those delegates to Scotland. They all wished to express to him their sincere thanks for his labours.

MR. BALLANTINE thanked the members for the kind expression of thanks for the little he had been able to do to foster the work of the Institute. It had, through unforeseen happenings, been less than he would have desired, but he wished to repeat what he had told them before, that he was a practical foundryman and a wholehearted Institute supporter.

The CHAIRMAN then referred to the Post-Congress tour to Scotland and asked the members to express the thanks of the Branch to the people who had done the work connected with it, especially Mr. Daniel Sharpe, the chairman of the committee, and Mr. John Bell, the secretary, to whose efforts the success of the visit was mainly due.

PRESIDENTIAL ADDRESS

MR. ERSKINE then delivered his Presidential Address, in the course of which he said:—

MR. BALLANTINE AND GENTLEMEN,

In view of the restricted time decided upon for the meeting, the form of this address has been modified, and contains no definite theme, but only remarks of a general character.

Amongst other things, the object of the Institute is to promote the intellectual welfare of the members by periodical meetings for the reading and discussion of scientific Papers on subjects connected with the foundry and allied industries. One is tempted to ask whether the Institute is achieving this particular object? What are the indications which might show whether the efficiency factor be high or low? New members, resignations, and average attendances at meetings all have a significance. The records show a slow but steady growth—an encouraging sign.

There must be some way, however, whereby members can still further improve its efficiency, and so create more practical interest in the Institute. The members of the Council have increased interest in the activities of the Branch, through the work necessary for conducting the affairs of the Branch, but what of the ordinary member? Do the present arrangements satisfy his thirst for additional knowledge?

In normal times the Scottish Branch enjoys attendances which compare favourably with any other Branch. There are, however, a large number of members who are irregular in attendance. It thus appears that their interest requires to be stimulated. But how is the improvement to be effected? All cannot be members of the Council. The Institute enables all classes of foundrymen, no matter what their status or particular sphere of activity, to meet on terms of equality and to hear and discuss Papers on any phase of the industry.

It may be that those responsible fail to provide Papers which are of interest to the majority of members. Having regard to the varied nature of the industry, it is extremely difficult to carry out the policy that the Papers presented shall cover the needs of the industry and the members as a whole Moreover, it appears to be difficult to obtain Papers of an essentially practical nature.

Subdivisions Suggested

In the present circumstances such words may appear to be ill-timed, but they may be of interest in the future. In the future, however, there may be sections formed within any Branch. These sections would represent the various phases of the industry—patternmaking, moulding, metallurgy, engineering, and so on. The sections would have their own committees, thereby increasing the number of members taking active part in the work of the Branch.

By arranging extra meetings, with short Papers and discussions, such an arrangement might provide an essentially practical side to the work of the Branch. Moreover, it is possible that by such an arrangement there would be provided a nursery for future Papers.

These remarks are not intended to be a criticism of the present excellent arrangements, but rather an attempt to anticipate the probable specialised demands of industry in the future.

Value of Works Visits

There have been criticisms of works visits, but a personal view is that the value of any such visit rests entirely with the individual. There are some people who cannot see the wood for the trees and others who see both the wood and the trees and are able to assimilate ideas born as a result of observation. Conferences also play an important part in the work of the Institute. Apart from the business associated with the presentation and discussion of Papers, opportunities are afforded for social contact and many lasting friendships have been formed. The annual volumes of Proceedings constitute an excellent and dependable reference library—excellent because of the practical value of the contents, and dependable because of the almost certainty that one will find suitable references to any particular subject.

In the industry itself, progress to-day demands that the foundryman with long practical experience should co-operate with the technician, and in addition there are now many men who enjoy both practical and technical experience. The old barriers between the practical and the technical man are breaking down, and industry as a whole is profiting thereby. Membership of the Institute with its wide range of members and consequent variety of thought and experience offers excellent opportunity for correlating the theory and practice of a particular phase in foundry practice.

In certain branches of the industry progress in recent years has been marked by improvements in mechanical moulding plant, sand-preparation units, core-drying facilities and dressing-shop equipment, to mention only a few. Suppliers of foundry equipment have made marked advances, and there is now hardly a phase of activity to which some useful form of mechanical equipment cannot be applied. The introduction of such equipment brings problems of its own but definitely leads to all-round improvement and reduction of human effort, in a reduced field of variables, and thereby increases organising efficiency.

Standardisation

There is definite scope for activity in the direction of standardisation. In the light-castings industry alone, and in certain classes of castings, the rule of some firms would appear to be that the less standardisation there is the better for the firm concerned. The multiplicity of patterns and designs of articles intended for the same duty is overwhelming. This policy would appear to be advantageous to the firm concerned in that the design adopted becomes more or less proprietary and in addition panders to the likes and dislikes of customers. An instance is provided by those articles of common usefulness known as rain-water gutters, the function of which is to intercept rain water as it runs off the roof of a building and to convey such water to down-pipes suitably disposed at some point in the system. One would imagine that a limited number of designs would cover the requirements. In practice each foundry has at some time adopted its own design, and generally these have multiplied with the result that there are now hundreds if not thousands of designs available of a casting destined to perform a particular duty.

A second example is a popular form of heating and cooking stove designed to perform a particular duty. Here again multiplicity of designs and dimensions demands the production of an extremely large number of patterns.

Costing Systems

The value of a proper costing system cannot be over-estimated; it would appear to be a basic necessity of any industrial undertaking, yet in many cases fiction rather than fact still obtains and in the end can only lead to confusion of results. The Institute has already done useful work in regard to costs, and it is hoped this encouragement will continue to be given.

Progress to-day demands also a survey of transport and handling facilities within a works. When one considers the amount of material handled daily there is obviously ample scope for the introduction of labour-saving equipment.

In conclusion it is necessary to stress the importance which technical meetings may assume in the time of national emergency. In addition to the Papers arranged for the session, opportunity will be afforded for the discussion of problems encountered in manufacture.

A vote of thanks to Mr. Erskine for his address was proposed by Mr. D. M. Campbell (Past-President) and seconded by Mr. H. W. Winterton (Past-President of the Institute).

A Paper on "Light Castings for Enamelling" was then presented by Mr. J. A. Donaldson. This and the subsequent discussion will appear in an early issue of the JOURNAL.

Effect of Casting Temperature on the Primary Microstructure of Cast Irons

By A. L. NORBURY, D.Sc.

(*Concluded from page* 341.)

Part IV.—EFFECT OF CASTING TEMPERATURE AND CHILLING ON THE MICROSTRUCTURE OF γ AND δ HYPO-EUTECTIC GREY CAST IRONS

γ *Hypo-Eutectic Grey Cast Irons.*—The term γ hypo-eutectic grey cast iron is used to indicate that the primary dendrites consist of γ-iron or austenite, to distinguish them from the primary dendrites formed in 14 per cent. silicon cast-iron compositions, in which the dendrites consist of the allotropic δ form of iron. This formation of δ-iron dendrites is due to silicon increasing the area of the δ-iron region in the top left-hand corner of the iron-carbon diagram, so that with high silicon contents the δ area occupies the whole of the area to the left of the eutectic.

Chill blocks cast in the γ hypo-eutectic grey cast-iron composition showed primary austenite dendrite structures in all ways comparable with those found in the γ hypo-eutectic white iron discussed in Part III. This was anticipated, since the primary dendrite formation is independent of whether the eutectic solidifies white or grey. Near the chill edge the eutectic solidified white, but the columnar dendrite structures were like those shown in Figs. 37 to 40. The equi-axed structures away from the chill are depicted in Figs. 47 to 50. These are comparable with the white-iron structures in Figs. 26 to 29, and it will be seen that the general effect of lower casting temperature, in preventing the aggregation of the austenite globules into dendrites, is the same in the grey iron as in the white iron already discussed.

In the iron illustrated in Figs. 47 to 50, the graphite eutectic structure was refined by treating the melt with titanium and carbon dioxide in order to make the dendritic structure stand out more clearly, since in coarse-graphite eutectic grey cast iron the eutectic austenite builds on to the primary dendrites and obscures them.

FIG. 47.—CAST HOT. HORIZONTAL SECTION 2 IN. FROM CHILL EDGE (UNETCHED). × 15.

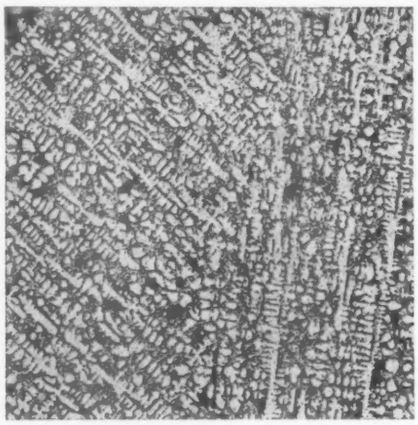

FIG. 48.—CAST MEDIUM HOT. HORIZONTAL SECTION 1¾ IN. FROM CHILL EDGE (UNETCHED). × 15.

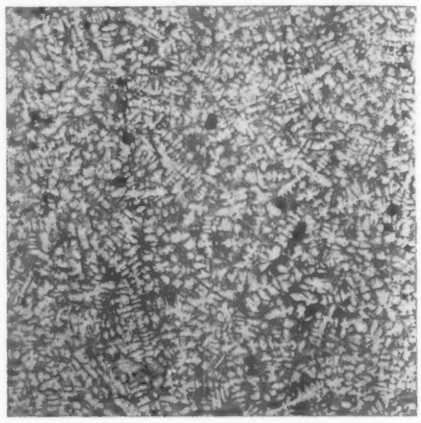

FIG. 49.—CAST COLD. HORIZONTAL SECTION 1½ IN. FROM CHILL EDGE (UNETCHED). × 15.

δ *Hypo-Eutectic Grey Cast Iron.*—Chill blocks cast in the δ hypo-eutectic grey iron composition shown in Table I had columnar and equi-axed microstructures similar to those of the above γ-iron, in so far as they consisted of dendrites plus fine graphite eutectic, but they showed an important difference in that their primary dendrite structures were not affected by casting temperature in the same way. That is to say, the δ-iron *equi-axed* structures in Figs. 51 to 54 correspond to the γ-iron structures in Figs. 47 to 50, but it will be seen that lower casting temperature has had little effect on the δ dendritic structures of Figs. 51 to 53, compared with its effect on the γ in Figs. 47 to 49. Even in Fig. 54, where the δ structure has been mechanically refined by casting in the pasty condition, it is very much more dendritic than the γ shown in Fig. 50 or the comparable *white iron* γ structure in Fig. 29.

The *columnar* dendrite structure in the δ-iron blocks cast "hot," "medium hot" and "cold" was also less reduced by lower casting temperature, being about 1¾ in., 1½ in. and 1 in long in the three cases. In the "pasty" cast δ-iron block, however, it was again absent, since the block solidified in a second or two. Otherwise, the δ columnar structures were very similar to those in the γ hypo-eutectic white and grey irons, as shown in Figs. 55 and 56.

Another illustration of the relative non-effect of lower casting temperature on the δ-iron dendrites is given in Figs. 57 and 58 of the vertical chill-edge structures. The difference is shown by comparing Figs. 57 and 58 with the corresponding γ-iron structures in Figs. 43 and 44, in which the dendrite-refining effect is marked. This difference in the effect of lower casting temperature on the primary dendritic structure in γ- and δ-irons is suggested to be due to the fact that γ-iron undergoes an allotropic change, or recrystallises, at the moment of solidification, while δ-iron does not.

Formation of Primary δ Dendrites.—On this view, the formation of δ-iron dendrites is de-

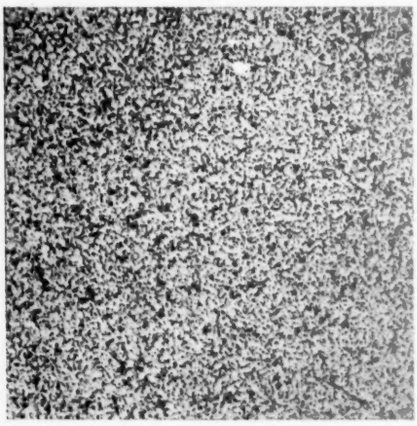

FIG. 50.—CAST PASTY. HORIZONTAL SECTION 1½ IN. FROM CHILL EDGE (UNETCHED). × 15.

FIG. 51.—CAST HOT. HORIZONTAL SECTION 2 IN. FROM CHILL EDGE. × 15.

FIG. 52.—CAST MEDIUM HOT. HORIZONTAL SECTION 1¾ IN. FROM CHILL EDGE. × 15.

picted diagrammatically in Fig. 59, which differs from Fig. 34 (*b*), showing the formation of γ-iron dendrites only in respect of the relative orientation of the globules before they aggregate to form dendrites. That is to say, in Fig. 34 (*b*) the allotropic change to γ-iron is assumed to have destroyed the relative orientation of the γ-iron globules, but in Fig. 59 there is no such allotropic change, and the δ-iron globules, in a given liquid crystal grain, are assumed to have the same crystalline orientation on formation. Consequently, lower casting temperature will have a much greater effect in preventing the aggregation of the non-orientated γ-iron globules in Fig. 34(*b*) into dendrites, than in preventing the aggregation of the oriented δ-iron globules in Fig. 59 into dendrites, which is the indication of the micrographs. A similar difference in the effect of casting temperature has been found between the α and β phases in both the copper-zinc and the copper-aluminium systems, and is attributed to a similar cause.

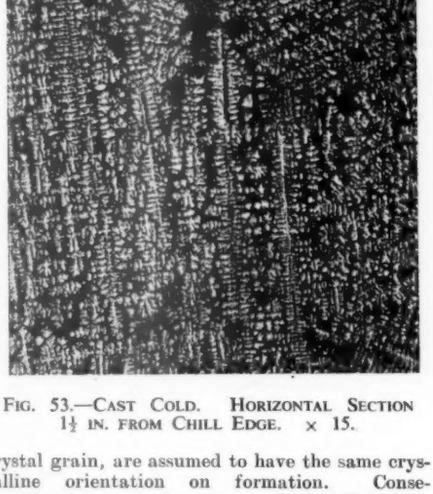

FIG. 53.—CAST COLD. HORIZONTAL SECTION 1½ IN. FROM CHILL EDGE. × 15.

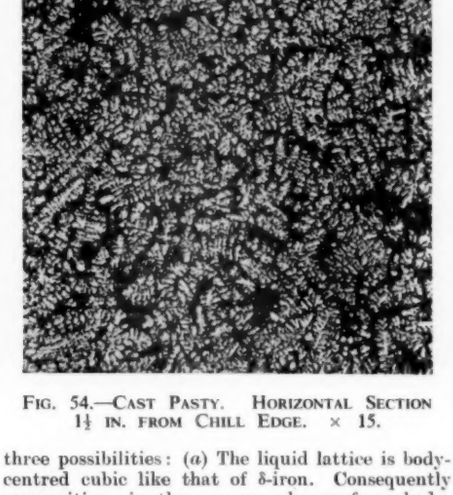

FIG. 54.—CAST PASTY. HORIZONTAL SECTION 1½ IN. FROM CHILL EDGE. × 15.

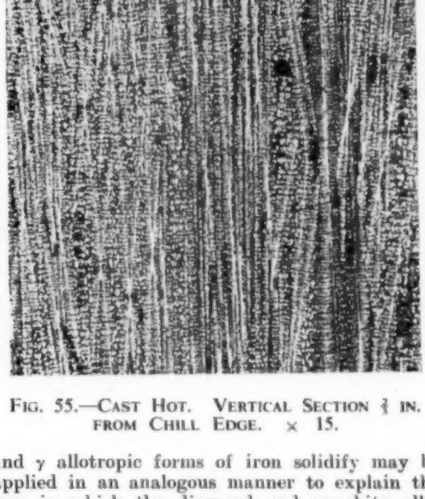

FIG. 55.—CAST HOT. VERTICAL SECTION ¾ IN. FROM CHILL EDGE. × 15.

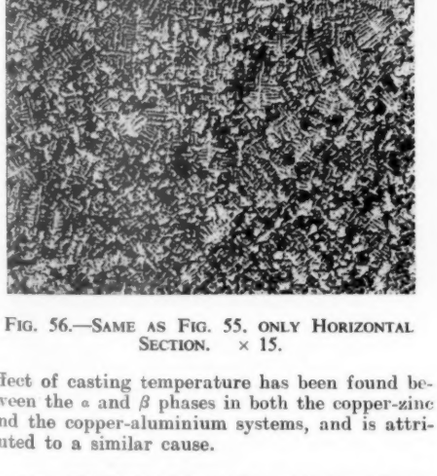

FIG. 56.—SAME AS FIG. 55, ONLY HORIZONTAL SECTION. × 15.

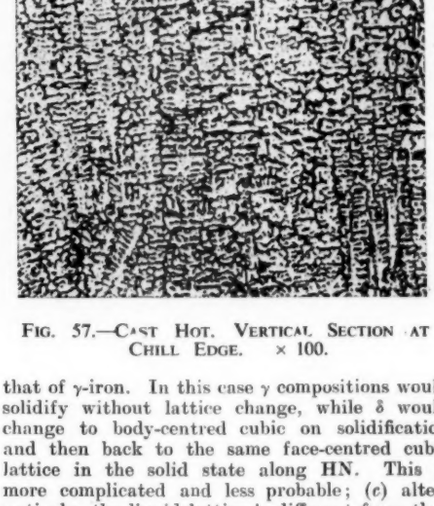

FIG. 57.—CAST HOT. VERTICAL SECTION AT CHILL EDGE. × 100.

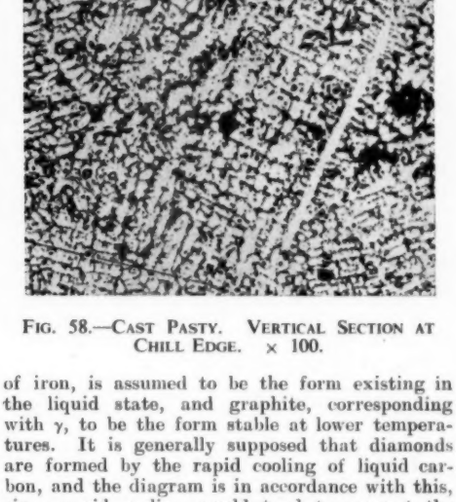

FIG. 58.—CAST PASTY. VERTICAL SECTION AT CHILL EDGE. × 100.

Part V.—THEORY OF THE SOLIDIFICATION OF IRON-CARBON ALLOYS

Solidification of δ- and γ-Iron. The above finding that lower casting temperature has a different effect on the dendritic structure of δ-iron as compared with γ-iron was actually anticipated from theoretical grounds, and led to the above experimental comparison being made.

The supposition was based on the following arguments relative to the iron-carbon diagram, which is shown diagrammatically in Fig. 60: (1) Liquid, carbon-free iron, as it approaches its freezing point, has some characteristic crystal lattice such as body-centred cubic or face-centred cubic, etc., as has been found in the case of low-melting-point metals in the liquid state. (2) If this liquid lattice does not alter in type above the line ABC as the carbon content increases, either δ- or γ-iron, or both, must solidify from the melt, with an accompanying lattice change, since solid δ is body-centred cubic and solid γ is face-centred cubic. (3) On this basis there are three possibilities: (*a*) The liquid lattice is body-centred cubic like that of δ-iron. Consequently compositions in the γ range change from body-centred cubic to face-centred cubic on solidification along BC. Compositions in the δ range, however, solidify along AB without lattice change, but undergo the same δ → γ lattice change in the solid state, along HN; (*b*) alternatively, the liquid lattice is face-centred cubic like that of γ-iron. In this case γ compositions would solidify without lattice change, while δ would change to body-centred cubic on solidification and then back to the same face-centred cubic lattice in the solid state along HN. This is more complicated and less probable; (*c*) alternatively, the liquid lattice is different from that of either δ or γ. In this case, more complicated and less probable lattice changes have to be assumed. Consequently, of the above three possibilities, (*a*) is the simplest and most probable. It also agrees with the different effect of casting temperature on the dendrite-structure formation in δ and γ cast irons, as discussed above in Part IV.

Put in another way, the argument is as follows: What happense to the δ → γ allotropic change line NH in Fig. 60 in the case of compositions to the right of the point B? Does the line continue into the liquid region above ABC,[a] or does it continue along BC? The present suggestion is that it continues along BC, as indicated in Fig. 60, and that the liquid above ABC has the same allotropic form and crystal lattice as δ-iron, and solidifies in accordance with 3 (*a*) above.

Solidification of Diamond and Graphite.—The above explanation of the way in which the δ and γ allotropic forms of iron solidify may be applied in an analogous manner to explain the way in which the diamond and graphite allotropic forms of carbon solidify. This is also shown in Fig. 60, in which, in the top right-hand corner, a hypothetical region has been drawn which corresponds in construction with the δ region on the left of Fig. 60. The diamond form of carbon, corresponding with the δ form of iron, is assumed to be the form existing in the liquid state, and graphite, corresponding with γ, to be the form stable at lower temperatures. It is generally supposed that diamonds are formed by the rapid cooling of liquid carbon, and the diagram is in accordance with this, since rapid cooling would tend to prevent the diamond → graphite allotropic change along UV, just as rapid cooling prevents the allotropic change when steels are quenched. Another analogy is that of pouring liquid sulphur into water, in which case the metastable, plastic allotropic form of sulphur is retained by quenching. Fig. 60 is also in accordance with the fact that solid diamond is metastable and decomposes into graphite on tempering.

[a] In the iron-copper diagram, two immiscible liquids are formed in the region above the point corresponding to B in Fig. 60. This may be due to the NH line, in this case, continuing from B into the liquid region.

Solidification of Iron Carbide and Graphite.—In Fig. 60, the diamond → graphite allotropic change VU is shown as continuing along the liquidus RDC, just as the δ → γ change NH is shown as continuing along BC. The deposition of solid graphite along RC is consequently analogous, in so far as the diamond → graphite allotropic change is assumed to accompany the solidification of carbon, to the deposition of solid γ-iron along BC.

In order to explain the solidification of carbide, it is assumed that when carbide is deposited along DC, the solidification of carbon is not accompanied by the diamond-to-graphite allotropic change; also that, owing to the composition of the melt, a metastable diamond-iron compound is formed instead of pure diamond. The composition of the metastable compound (Fe_3C) is indicated diagrammatically by DF.

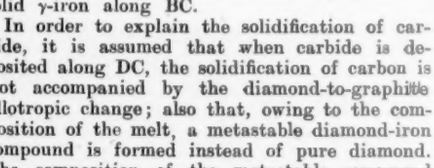

FIG. 59.—THEORY OF δ-IRON DENDRITE FORMATION BY GROWTH PLUS AGGREGATION (BY PROGRESSIVE GROWTH, AS IN FIG. 34 (*a*)).

This affinity of iron for the diamond form of carbon has a stabilising effect on the latter, and this effect increases as the ratio of iron to carbon increases. Consequently, in the γ solid solution deposited along BC, in which the carbon is also assumed to be in the diamond form, it is stable owing to the affinity of the surrounding iron atoms, and not metastable. Iron carbide not in solid solution is, however, metastable and, like diamond, decomposes into graphite on tempering.

The author thanks the Council of the British Cast Iron Research Association for permission to publish the present results. Credit for the micrographs is due to Mr. H. Morrogh and other members of the staff.

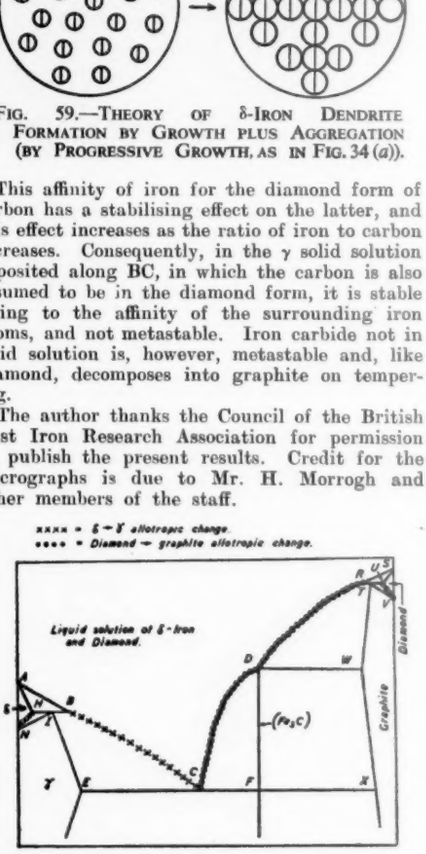

FIG. 60.—THEORY OF ALLOTROPIC CHANGES IN IRON-CARBON ALLOYS (DIAGRAMMATIC AND NOT TO SCALE).

Appendix I. — EFFECTS OF ALLOYING ELEMENTS ON THE STABILITY OF IRON CARBIDE

In connection with the stability of iron carbide, discussed above, it is suggested that those alloying elements which have a graphitising action are those which form solid solutions in cast iron, and that those which have a carbide-stabilising action are those which form compounds.

For example, the chief graphitising elements aluminium, silicon, cobalt, nickel and copper all form solid solutions. On the other hand, the elements which have been found to stabilise the carbide, boron, magnesium, sulphur, vanadium, chromium, manganese, arsenic, selenium, molybdenum, tin, antimony, tellurium, tantalum and tungsten, have all been found to form compounds such as carbides, sulphides, iron compounds, etc., visible as separate phases in the microstructure.

The case of aluminium is particularly significant, since first additions of it form a solid solution and have a powerful graphitising action, while additions above a certain figure form a compound which has a powerful carbide-stabilising action. Similarly, additions of phosphorus reduce the combined-carbon content of grey cast iron, but the carbide nearest to the phosphide compound visible in the microstructure is always the last to decompose. It seems probable that this phosphide has a carbide-stabilising action, while phosphorus in solid solution has a graphitising action.

Other elements such as chromium, manganese and molybdenum, when alloyed, partly form carbides and partly enter into solid solution in cast iron, their distribution in this manner depending on the amounts present and on the amount of carbon present. In the case of chromium, for example, it has been found* that in steels, all of it forms carbide and none goes into solid solution until it exceeds 4.3 times the amount of carbon present.

The indication consequently appears to be that compounds in cast iron favour the formation of the iron-carbide compound. This may be connected with the similar nature of the attractive forces between the constituent atoms in the compounds and in the iron-carbide compound.

Elements in solid solution, however, have the opposite effect of making iron carbide unstable or of graphitising it. This may be connected with the distortion of the iron lattice produced by elements in solid solution, since elements like aluminium and silicon, the atoms of which differ considerably in size from those of iron, have a much more powerful graphitising action than elements like cobalt, nickel and copper, the atoms of which are not very different in size from those of iron. This distortion of the iron lattice, by tending to communicate itself to the iron-carbide lattice on account of the attractive forces between the iron atoms in each, may make the latter unstable.

* C. A. Edwards and A. L. Norbury, Journal of the Iron and Steel Institute, 1920, No. II, p. 481.

How to Preserve Sandbag Revetments

TWO METHODS OF TREATMENT

On the basis of present information two types of preservative are considered to be suitable for application to sandbag revetments, points out the Ministry of Home Security in a technical circular. These preservatives are respectively a creosote or tar distillate, used as a water emulsion, and a solution of an organic copper salt in creosote made up into an emulsion. The former is more widely available than the latter and is suitable for treatment of revetments in position which have already deteriorated by being exposed to the weather for some time. The latter is more potent but it is also more expensive and its use will not generally be justified unless the bags are in good condition and unless it is desirable to take down the whole revetment, treat all the bags and then repile them.

The application of the preservatives should conform with the following specification:—(1) A creosote or tar distillate of medium creosote type applied as a water emulsion in such a quantity as to give on the exposed portion of the bag a coating of creosote not less than one-fifth of the normal dry weight of the fabric exposed. This is given approximately by a 25 per cent. creosote emulsion when sprayed on the bags to give a thorough coating, completely satisfying the absorption of the fibres. The creosote should comply with British Standard Specification No. 144/1936 "Creosote for preservation of timber." Any normal emulsifying agent may be used and the following is given as an example of the process of emulsification. The following ingredients are used:—65 parts creosote, 35 parts water, 1.2 parts oleic acid, 0.8 parts casein, and 0.36 parts sodium hydroxide, the three latter forming the emulsifying agent. The agent is dissolved in water and the two fluids are mixed in a jet similar to that of a cream-making machine. An emulsion prepared in this way should be stable and can be transported in drums or kegs. Before use it should be diluted with water to a suitable consistency for spraying so that the creosote content does not fall below 25 per cent.

(2) An organic copper salt is dissolved in creosote or tar distillate of the type indicated in (1) above, the solution then being made up into an emulsion with water, by the use of a special type of emulsifying agent. The copper salt should be one of an organic fatty acid of high molecular weight (such as, for example, copper oleate). The organic copper salt should be added in the proportion of 16 per cent. of the weight of the creosote and the whole should be emulsified with water. When sprayed on the bags it should be applied as 20 per cent. emulsion. This will leave 0.5 to 1.0 per cent. of metallic copper, estimated on the normal weight of the fabric when conditioned under ordinary atmospheric conditions.

Apply by Spray

In applying the emulsions attention should be given to the manufacturer's instructions for dilution with water immediately before use to obtain a proper spraying consistency. The diluted solutions do not keep, and it is essential that they should not be diluted further than is necessary to obtain the quantity of creosote on the bags indicated in (1) above. Either of the emulsions should preferably be applied by means of a spray, though a brush application is permissible. Care should be taken to coat thoroughly any seams visible on the face of the pile and to work the emulsion well into the seams. The spraying should be done with a paint spray or horticultural spray, and the stirrup-pump recommended for A.R.P. fire protection may be used if no other spray is available. Care is needed to avoid fire risk during application as when handling creosote in the ordinary way. Naked lights should not be allowed in the vicinity of the work and workers should not smoke whilst spraying. The freshly-creosoted revetments will have the strong odour characteristic of creosote, but this will decrease to an unobjectionable amount in a few days. As creosote may cause permanent stains, suitable measures should be taken to protect the surface of buildings against which the bags are placed, whilst spraying is in progress.

In order to obtain the best possible penetration into the revetment, the preservatives should not be applied immediately after a heavy rain. They will be far more effective if the pile is given a reasonable time for drying after rain. It will be desirable to repeat the treatment, and this should be done at intervals not exceeding three months.

Stainless Ledloy

According to a note in "Steel," the Allegheny Ludlow Steel Corporation are to manufacture lead-bearing stainless steel incorporating the Ledloy process.

Melting Special Cast Irons in the Cupola*

The cupola is still the most common form of melting unit in iron foundries, and consequently most nickel cast iron (up to 2 per cent. nickel) is produced in this type of furnace. The cupola probably owes its popularity to the comparatively low initial outlay involved, and to its adaptability of working, coupled with low melting and maintenance costs.

Since widely varying designs of cupolas appear to give almost equally successful performances, it is extremely difficult to give recommendations on cupola design as applied to the melting of cast-iron compositions to be used as a base for nickel additions, or for melting nickel alloy cast iron. In recent years developments in cupola design have been directed towards improved combustion of the fuel, with consequent lowering of melting costs coupled with the production of good clean metal which can be tapped at higher temperatures than those formerly obtainable.

Internal Diameter and Melting Rate

The internal diameter determines the melting rate, and consequently the size of cupola or cupolas installed in any one foundry will be selected according to the weight of metal which can be "cast up" per hour and to some extent by the maximum weight of individual castings to be produced. For normal working, the melting rate should be 10 to 12 lbs. of metal per hour for each square inch of bore at the melting zone. This figure has been derived from observations taken from a considerable number of cupolas of modern design.

Capacity of "Well" and Height of Tuyeres

The size of the cupola well, and consequently the height of the tuyeres from the cupola bottom, will depend on the amount of metal it is desired to store between taps. This height may vary from 12 in. up to 30 in. or more.

If high-strength nickel cast iron, low in total carbon, be desired, the well should not be deep. On the other hand, in order to obtain uniformity of composition, the "well" should be capable of holding at least two complete charges. In the production of nickel alloy cast iron, it is often advantageous to reduce the weight of the individual charges below the recognised normal in order to be able to collect not less than three charges, between taps. This promotes greater uniformity of composition. For the above reasons, it will be seen that it is advisable to seek an intermediate height which will most nearly fulfil these conditions.

Blast Main and Wind Belt

The shape and general layout of the blast main should avoid all complicated and sharp bends and allow an easy flow of air, at steady pressure, with the absolute minimum of friction. The wind belt should be sufficiently large to allow an adequate volume of air to be delivered into the cupola at a constant pressure.

Tuyere Area and Shape of Tuyeres

The ratio of tuyere area to the area of the cupola bore at the tuyere level varies very greatly in different types of cupolas. However, it is generally agreed that a ratio of one-fifth to one-seventh of the cupola area at that level is advisable. Some authorities recommend a 1:4 ratio, while there are many cupolas in operation where the ratio is nearer 1:15. In general a "soft" blast is desirable, but if the tuyere area is too great, the velocity of the blast entering the cupola may be too low to give adequate penetration to the centre. Perhaps this fault is less often met with than the reverse, where very small tuyere areas result in excessive air velocities which cause uneven pressure and excessive erosion of the refractory lining. An even spread of the air supply over the charges is also desirable, and consequently the tuyeres should be distributed and shaped with that object in view.

Height of Charging Door

The height of the stack from the top of the tuyeres to the bottom of the charging door should be sufficient to promote efficient preheating of the charges and consequent cooling of the ascending gases. In far too many cases, this aspect of cupola design is neglected, with loss of efficiency. For example, for a cupola lined to 40 in. internal diameter a height of 15 to 18 ft. between the top of the tuyeres and the bottom of the charging door is not excessive. Even in modern cupolas the importance of this dimension is often overlooked.

Air Blast

The volume of air required to melt charges in a cupola depends on the total weight of carbon in the fuel, plus a sufficient excess to make up for losses. The air must be delivered at sufficient pressure to penetrate to the centre of the cupola and to overcome the resistance of the constituents of the charge in the cupola stack. The pressure will depend on the tuyere area and on the diameter of the cupola. The latest tendency is to supply a sufficient volume of air at a pressure controlled to give a "soft" blast, at the same time fulfilling other conditions.

Theoretically 1 lb. of cupola coke of average composition requires about 140 cub. ft. of air for complete combustion. In actual practice a certain margin must be allowed above this figure. For normal working it is usual to aim at 160 to 180 cub. ft. of air per lb. of coke. If the cupola is working satisfactorily this should give a figure of approximately 28,000 to 33,000 cub. ft. of air per ton of metal melted per hour. Where considerable percentages of steel scrap are being melted and the coke ratio is greater than normal this figure may reach 36,000 cub. ft., or even more. It is essential that measurement of the volume of air entering the wind belt is accurate and that there is no risk of leakage beyond the point of measurement. Unreliable air volume measurement may lead to a considerable amount of trouble. If possible the measurement should take place at two points, namely, in the main air-line and in the wind-belt. This will give a reliable means of checking air losses due to leaks in valves or in the wind belt.

Much attention has been paid in recent years to the performance of cupolas of the Balanced Blast type as developed by Fletcher and the British Cast Iron Research Association. In this cupola the air flow through the main (bottom row) of tuyeres can be regulated by valve mechanism, and when these are partially closed, the rate of flow through the upper or auxiliary tuyeres is increased. In this way the air supply to various parts of the bed is balanced to suit particular conditions.

By this means not only is there a definite economy in fuel consumption, but a considerable degree of superheating may be attained.

It is very important in all types of cupolas to obtain a correct ratio of air to coke, since by this means carbon pick-up is more easily controlled and regularity of total carbon content maintained. When the volume is too low unduly slow melting and cold metal result. If the volume is much too high, oxidation takes place and there is an excessive loss of silicon and manganese during melting. Oxidised, badly melted cast iron is usually characterised by having a short freezing range with consequent loss of life and castability. Such a condition is readily recognised in a practical way by the premature freezing of risers and the formation of heavy skulls in ladles and shanks.

Air blast is normally supplied by means of either a positive blower or a fan. The modern tendency inclines towards the adoption of the fan type, because of its greater flexibility and ease of output control. A correctly designed fan, driven by a variable-speed motor, will be capable of adjustment to supply a constant volume of air under widely varying furnace conditions.

Melting Coke

In the melting of cast iron in the cupola much of the success of the operation depends on the quality or suitability of the coke used as fuel. There are many excellent foundry cokes available, but unfortunately there are no absolute tests for ascertaining the true value of any brand, apart from actual trial under operating conditions in the cupola.

Chemical analysis gives much information and when this is judged along with its physical properties a fairly close estimation may be made of its quality as a cupola fuel. However, this is not the whole story. Such properties as reactivity to carbon dioxide, porosity, combustibility and other properties also play an important part in deciding which of two cokes of similar chemical composition, size, brittleness, strength, resistance to compression, etc., will prove the best under actual cupola melting conditions. The chemical composition of a good quality foundry coke should fall within the following limits:—

Fixed carbon: Not less than 86 per cent. but preferably over 90 per cent.

Volatile Matter: Not over 2 per cent.

Ash: Not more than 10 per cent. but preferably not more than 8 per cent.

Sulphur: Not more than 1.0 per cent. but preferably not more than 0.60 per cent.

Compressive Strength or Shatter Test

Nearly the whole of the foundry coke used to-day is made by the by-product process in coke ovens, the older beehive process having been discontinued in many districts. In the coke oven method water is used to quench the coke as it is dumped from the retorts and under this treatment some brands of coke become more brittle than others. Good foundry coke must not shatter under shock and must be strong enough to support the metal charges during cupola melting. Other things being equal the stronger the coke, the better it generally is for cupola melting. The so-called "shatter test" has been evolved to endeavour to form some estimate of the strength of different brands of coke.

Porosity and Structure

All kinds of coke are cellular in structure, the walls which enclose the cells being non-porous. Under forced draught such a carbonaceous material burns readily. The degree of porosity, coupled with the size of individual cells, gives some criterion as to the suitability of a particular coke. If the cells are large and the intervening walls thin, combustibility may be excellent, but the coke is likely to be too brittle and easily crushed. Therefore it is desirable to compromise with a coke which has sufficient strength and resistance to crushing, combined with a reasonable degree of combustibility.

Size of Coke

The average size of a brand of coke is very important. Other qualities being equal, a moderately large, regularly sized coke is much to be preferred to small or irregularly sized material. A coke of good strength and high "hardness" is more likely to be of good average size than a weak, friable coke, because the latter is likely to be readily crushed during transport and rehandling.

* From information supplied by the Research and Development Department of the Mond Nickel Company, Limited.

In most cases, coke in 5 in. to 8 in. square lumps or equivalent shapes will always be found satisfactory. In making up the "bed" it is advisable to select large coke, since the height of the coke bed, not the weight of the coke, is the important item in correct cupola practice. This is particularly worthy of attention when producing high steel-mix types of nickel cast iron. Another advantage to be derived from coke of reasonably large size is that it keeps the furnace burden open and gives much less resistance to the free passage of air than when small coke is used.

Reactivity

This may be described as the capacity of a coke to react with carbon dioxide. This is undoubtedly an important quality in coke used for cupola melting, but there is still a considerable amount of doubt on the subject. Authorities vary greatly in correlating this quality with the structure and other characteristics of different brands of coke.

To sum up, it will be seen that it is very difficult to predict the behaviour of any individual brand of coke by its chemical and physical properties. From the practical foundryman's point of view, it is desirable to select coke of suitable size with a high degree of strength and "hardness" and capable of bearing the furnace burden when in an incandescent state. Such a coke will usually be associated with density of cell structure, and a high shatter test.

Catalogues Received

Slings. A very useful eight-page brochure has recently been issued by Herbert Morris, Limited, of Loughborough, dealing with the very important question of slings. The natural tendency to use the nearest sling at hand is rightly deprecated as being dangerous. The pamphlet describes and illustrates the great variety of slings this firm now make available for industry, all of which are properly standardised and tested for the duty imposed. Numerous tables are included to give the safe lifting loads, usually related, where appropriate, to the angle of the legs of the slings.

Machine Tools. A catalogue received from William Asquith, Limited, of Halifax, covers horizontal drilling, boring and milling machines. Amongst the illustrations it is pleasing to see the inclusion of the castings before assembly, because their complexity and cleanliness make them of distinct interest to foundrymen.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

511,149. EVANS, O. (Hein & Company vorm. Haigerer Hutte). Method of and apparatus for producing slag wool, rock wool, and the like.

511,183. EYERMANN, P. Method and apparatus for casting ingots.

511,197. RUSSELL, G. A. V., and IMPERIAL CHEMICAL INDUSTRIES, LIMITED. Coiling apparatus, more particularly for extruded wire or rod.

511,224. WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY. Automatic control of thickness of strip in rolling-mills.

511,260. BUDERUS'SCHE EISENWERKE. Method of improving the material properties of cast bodies.

511,268. BRAUNSCHWEIGER HUTTENWERK GES. Manufacture of compound cast bearings.

511,279. LOBKOWITZ, G. B. Methods of rolling sheet, strip, and the like.

511,236. ALLIANCE MACHINE COMPANY. Extractor head for ingot strippers.

Briquettes as a Substitute for Pig-Iron

UTILISATION OF CAST-IRON BORINGS AND TURNINGS

The question of briquetting cast-iron borings and turnings has previously been referred to in our columns. Some few plants have been installed for the duties referred to, and in every case their operation has proved economically advantageous. We feel justified in again referring to the subject, as during the present international crisis it is necessary to study methods and practice which, in normal times, would receive little, if any, consideration. In economic warfare, every manufacturer is under an obligation to make the fullest use of the material available.

PRESS FOR BRIQUETTING CASE-IRON BORINGS.

Clearly, the large quantities of cast-iron swarf produced by boring and turning must be returned to the foundry for remelting; it is merely a question of the form in which such material is to be returned. Obviously, no justification can be found for the practice of feeding the swarf to the cupola in a loose condition. Apart from oxidation, a high percentage will pass out of the cupola due to the blast, and the total loss with loose swarf may easily be as high as 50 per cent. If the swarf is packed in containers, there will be a substantial reduction in the losses. At the same time, there will be considerable oxidation with a loosely-packed container, and a proportion of the charge will also be lost in the air blast; in addition there will, of course, be the cost of the containers and the packing. Within wide limits, the losses will fall proportionately as the density of the material charged increases.

Under suitable presses, and without the use of any form of binder, briquettes are being produced from cast-iron borings and turnings, with a density of at least 70 per cent. that of solid cast iron, whilst the cost of production does not exceed 7s. per ton. Systematic research in conjunction with practical experiment on a commercial scale has demonstrated that cast-iron briquettes show a loss of not more than 5 to 10 per cent. when melted alone and only 3 to 4 per cent. when melted with pig-iron in the usual proportions of 80 to 20. The loss with the mixture is thus favourably comparable with that when melting pig-iron alone.

Moreover, tests show that a mixture of pig-iron and swarf briquettes yield considerably better castings, particularly from the point of view of greater density, toughness and strength, so that to a considerable extent they may be substituted for the expensive brands of iron used in making high-quality castings.

Action of Briquette

The action of the briquette may be explained as follows:—By virtue of their own low-carbon contents, materials added to an iron mixture to reduce the total carbon do not appear in practice to give quite the desired results, since they absorb carbon again during fusion. With cast-iron swarf briquettes, however, the contrary appears to be the case. Compared with loose swarf, the compact form of the briquette protects the material against strong oxidation in the upper part of the cupola and against slagging off. At the same time, the structure, although the briquettes may have a specific gravity of 6 to 7, is loose compared with the denser pig-iron, so that the graphite is burnt off just above the fusion zone. The subsequent carburising process occurring during the period of fusion cannot quite replace the carbon lost in this way. The net result would therefore appear to be a considerable reduction in total carbon.

Confirmation of this is furnished by a well-known foundry which is producing the highest grade of castings for internal-combustion engine cylinders, etc., their experience being that the cast-iron swarf briquettes give the same results as steel scrap, and they replace also an equal weight of high-grade irons. From the foregoing it would seem that the value of the briquette is higher than that of ordinary pig-iron.

The following figures, which show the economy resultant from the practice, are not assumed; they are the results obtained in everyday working practice.

To produce 1 ton of melted iron:—

	£	s.	d.
16 cwts. of pig-iron at, say, £5 per ton	4	0	0
4 cwts. of alloy iron at, say, £7 per ton	1	8	0
	5	8	0
Allow 4 per cent. for loss in melting		4	4
	£5	12	4
With cast-iron swarf briquettes:—			
16 cwts. of iron at £5 per ton	4	0	0
4 cwts. of c.i. swarf, valued at 20s. per ton plus cost of briquetting ...		6	9
	4	6	9
Allow 4 per cent. for loss in melting		3	6
	£4	10	3

The press illustrated is made by Wm. Johnson & Sons (Leeds), Limited.

Oil as a Grinding Lubricant and Coolant

In "Grits and Grinds," Vol. XXX, No. 2, the house organ of the Norton Grinding Wheel Company, which is issued in this country through Alfred Herbert, Limited, of Coventry, a particularly well-balanced article deals with the subject of the replacement of water by oil in grinding processes. It is not recommended where dry grinding is practised, as in fettling shops, that the use of oil would be of benefit, but in cases such as where grinding is used for threading, it may be of advantage. It is apparent from the article that the system is finding increasing application in the United States. Progress is shown to be irregular, and sometimes the smaller sizes of components may be so treated, but the larger ones do not lend themselves to such treatment.

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Melts Brass in 15 minutes

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The Cumming
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MOULDING MACHINE

•

The Cumming
ELECTRIC RIDDLE

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Head Office and Works—
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PLUMBAGO
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The Week's News in Brief

Trade Talk

THE EMPLOYEES of G. & J. Weir, Limited, Glasgow, have contributed £1,420 to charitable institutions in Glasgow and the West of Scotland.

THE NEWHAVEN ENGINEERING COMPANY, LIMITED, have removed their works and offices from West Grinstead, Horsham, Sussex, to 40, St. George's Road, Brighton, 7.

THE CITY AND GUILDS OF LONDON INSTITUTE have informed us that, so far as circumstances permit, the Board will hold the 1940 series of examinations in Foundry Practice and Pattern-making as usual.

ANGUS BUCHANAN, son of Captain Angus Buchanan, the well-known explorer and writer, lost an arm in an accident which occurred in the works of Brown Bros. & Company, Limited, Rosebank Iron Works, Edinburgh.

A WAR BENEVOLENT FUND is being formed by the employees of the English Steel Corporation, Limited, Sheffield, with the full co-operation of the management, both financially and in organisation. During the last war over £50,000 was raised for a similar fund.

THE BOARD OF TRADE have made an Order (the Export of Goods (Prohibition) (No. 2) Order, 1939, Amending (No. 10) Order, 1939), which came into force on November 15, under which sugar-making and refining machinery no longer requires export licences for any destination.

THE club house of Rotherham Golf Club at Thrybergh is to be taken over by Hadfields, Limited, the Sheffield steel manufacturers, as additional office accommodation for the period of the war. The company is also contemplating the establishment of new works, to employ 1,000 to 1,500 men, in the Swinton area. A site of about 25 acres has been obtained for the new works.

CONDITIONS in the Luxemburg iron and steel industry have improved during the past few weeks. Large orders have been placed by Belgium, Great Britain, Germany, Holland and Scandinavian countries. Working days this month are expected to total 22. Iron and steel prices are rising. The iron-ore industry is very active and a heavy advance in ore prices has taken place.

STANTON IRONWORKS COMPANY, LIMITED, have prepared for the use of technical institutes a number of industrial films depicting the processes they employ. Of particular interest to our readers are the two which cover the manufacture of pig-iron and spun-iron pipes. These films, which are available for showing at technical meetings, are on standard 16 mm. "non-flam" stock and are made self-explanatory by means of sub-headings. Each film runs for about 16 minutes. Full information and details as to when the films are available may be obtained from the Stanton Ironworks Company, Limited, near Nottingham.

INDUSTRY had been successfully brought into the business of munitions production—while at the same time normal industry and our export trade had been interfered with as little as possible, said the Director-General of Munitions Production recently. We had in hand now, he stated, probably the biggest industrial task which had ever been undertaken in this country. Goodwill had been forthcoming in full measure from employers and workers alike. The behaviour of the men in the shops had been splendid. Some of them had tackled completely new tasks in an astonishing way. It was easy to spoil several thousand pounds' worth of work by one slip, but men completely new to the job had carried on most competently. The Director-General paid warm tribute to the director and staffs of the royal ordnance factories. For years they maintained their efficiency on little work, and then were called on to collect greatly augmented staffs, which were proving surprisingly efficient. Home production would be supplemented by supplies from oversea. Shells were arriving from Canada, where at present there was a mission sent out by the Ministry of Supply.

THE South African Iron & Steel Industrial Corporation, Limited, have placed with the Woodall-Duckham Vertical Retort & Oven Construction Company (1920), Limited, an order for a second complete by-product coking installation to be built at their Iscor Steelworks, near Pretoria. The value of this order is just on £475,000. The new oven battery will comprise 45 top-charged, W-D Becker coke ovens, designed for blast-furnace gas underfiring. The ovens will be 40 ft. 8 in. long, 13 ft. high, and 16 in. average width, and the battery will be capable of carbonising 960 tons of washed coal a day. The new battery will be laid out on a new site, but on the by-product side advantage will be taken of the original facilities for extension. The contract provides for two sets of electro-detarrers for the extended plant, and for a new concentrated ammonia plant capable of manufacturing liquor of 25 per cent. strength. The capacity of the benzol plant will be doubled, provision being made at the same time for the production of pure toluol. Finally, a pipe-still type of tar distillation plant has been adopted to deal with 100 tons of crude tar per day, and this installation will produce finely-cut fractions, including a suitable wash oil for benzol recovery.

AT a representative meeting of the Federation of British Industries Executive Committee, under the chairmanship of Lord Dudley Gordon, a full review of the Federation's activities during the past month was presented. Reports were received on British export policy, the Control of Prices Bill, and war risks insurance, in reference to which last the Committee urged that premiums already paid should cover the insured up to January 2. The premium originally fixed was 30s. per cent. for three months. The first month's premium having now been remitted, it can be taken that the premium of £1 per cent. was regarded on October 3 as adequate cover for a period of two months. More than half this period has passed without claims, therefore the same premium should be sufficient for the seven weeks from now to January 2. On the question of taxation policy, and particularly in relation to excess profits tax, a special sub-committee has been appointed to consider the whole matter. Relevant information is being sought from affiliated trade associations, and the sub-committee's proposals will be brought before the Grand Council for consideration in January. The problem of exports was also considered, and it was decided to continue close contact with the Board of Trade, and to press the view that exports should be given equal precedence with the requirements of the Service Departments.

Obituary

MR. NEVILLE WILLIAM FAIRBAIRN WAILES-FAIRBAIRN, a director of Fairbairn Lawson Combe Barbour, Limited, textile and general engineers, of Wellington Foundry, Leeds, died in a York nursing home recently from injuries he received in a hunting accident. He was 47 years of age.

Reports and Dividends

Johnson & Phillips, Limited—Interim dividend of 7½ per cent.

Atlas Steel Foundry & Engineering Company, Limited—Final dividend of 17½ per cent. and a cash bonus of 10 per cent., making 42½ per cent. for the year to September 30.

Drake & Gorham, Limited—Net profit for the year ended June 30, after making all provisions, including income tax at 7s. in the £, £538; brought in, £2,775; carried forward, £3,314.

John I. Thornycroft & Company, Limited—Net profit for the year to July 31, £179,171; brought in, £45,456; ordinary dividend of 10 per cent.; to benevolent fund. £10.000; to reserve, £100,000; carried forward, £53,877.

New Officers of Institute of Metals Nominated

Lt.-Col. the Hon. R. M. Preston, D.S.O., has been nominated President of the Institute of Metals for the session 1940-41. The President-designate is managing director of Rio Tinto Company, Limited, and a director of a number of metallurgical concerns. Other nominations are:—*Vice-Presidents*: Dr. S. F. Dorey, D.Sc.; Engineer Vice-Admiral Sir George Preece, K.C.B., and Mr. A. J. G. Smout. *Honorary Treasurer*: Lt.-General Sir J. Ronald E. Charles, K.C.B., C.M.G., D.S.O. *Members of Council*: Dr. W. E. Atkins, D.Sc.; Mr. G. L. Bailey, M.Sc.; Mr. F. C. Braby, M.C., B.Sc.; Col. P. G. J. Gueterbock, D.S.O., M.C., T.D., M.A., and Prof. D. Hanson, D.Sc.

Personal

SIR BERNARD DOCKER, K.B.E., has been elected chairman of the Birmingham Small Arms Company, Limited, in succession to Sir Alexander Roger, who, owing to pressure of work in other directions, has had to resign.

MR. J. T. RYMER has joined the board of Blackstone & Company, Limited, of Stamford, Lincs. Mr. Rymer was recently elected to the board of R. A. Lister (Marine Sales), Limited, which markets Blackstone engines for marine purposes.

MR. HAROLD G. JUDD, C.B.E., has been appointed Controller of Salvage in the Ministry of Supply. Mr. Judd is a partner in Mann, Judd, Gordon & Company, chartered accountants, and secretary of the National Ironfounding Employers' Federation.

MR. M. DOUGLAS, director and general manager of the Refractory Brick Company of England, Limited, Steetley, Notts, has been appointed a director of the British Periclase Company, Limited, at West Hartlepool, to develop the production of synthetic magnesite.

MR. G. J. JACKSON, managing director of the Woodall-Duckham Company, left last week for South Africa in connection with the large contract for coke ovens and by-product plant which the company has received from the South African Iron & Steel Industrial Corporation, Limited.

MR. A. W. GARRETT has been appointed Chief Inspector of Factories in succession to Sir Duncan Wilson, who retires from the public service on December 27. Mr. Garrett entered the Factory Department of the Home Office in 1906, was promoted Superintending Inspector, in charge of the Midland Division, in 1932, and became Deputy Chief Inspector of Factories in January, 1937.

MR. T. P. N. BURNESS, M.I.M.E., M.I.P.E., who was recently appointed managing director of William Asquith, Limited, Halifax, following the resignation of Mr. J. L. Munn, has now taken up his duties with that concern. Prior to this appointment Mr. Burness, who is a native of Motherwell, where he received his early engineering training, was works director of Ruston & Hornsby, Limited, Lincoln, with which firm he was associated for 23 years. He is very well known in machine-tool circles as well as in many other branches of the engineering industry.

Wills

REEVES, A. B., of Birmingham, brass-founder	£36,208
WOODS, V. S., chairman of Ransome & Marles Bearing Company, Limited	£25,433
EVERSHED, SYDNEY, electrical engineer, director of Evershed & Vignoles, Limited	£67,395

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"POBOTTLE"—Metals and alloys. High Duty Alloys, Limited, 89, Buckingham Avenue, Trading Estate, Slough, Bucks.

"BRABRO"—Metals for welding, soldering and brazing. Francois Cementation Company, Limited, 701, Salisbury House, London, E.C.2.

New Company

G. A. Vandervell (London), Limited, 5/6, Bucklersbury, London, E.C.4—Capital, £100. Ironfounders, brassfounders, etc. Directors: G. A. Vandervell and M. P. Foster.

Forthcoming Events

Institute of British Foundrymen

NOVEMBER 25.

London Branch:—"Foundry Layout," Paper by F. J. Cook, M.I.Mech.E., at Charing Cross Hotel, London, W.C.2, at 2 p.m.

NOVEMBER 30.

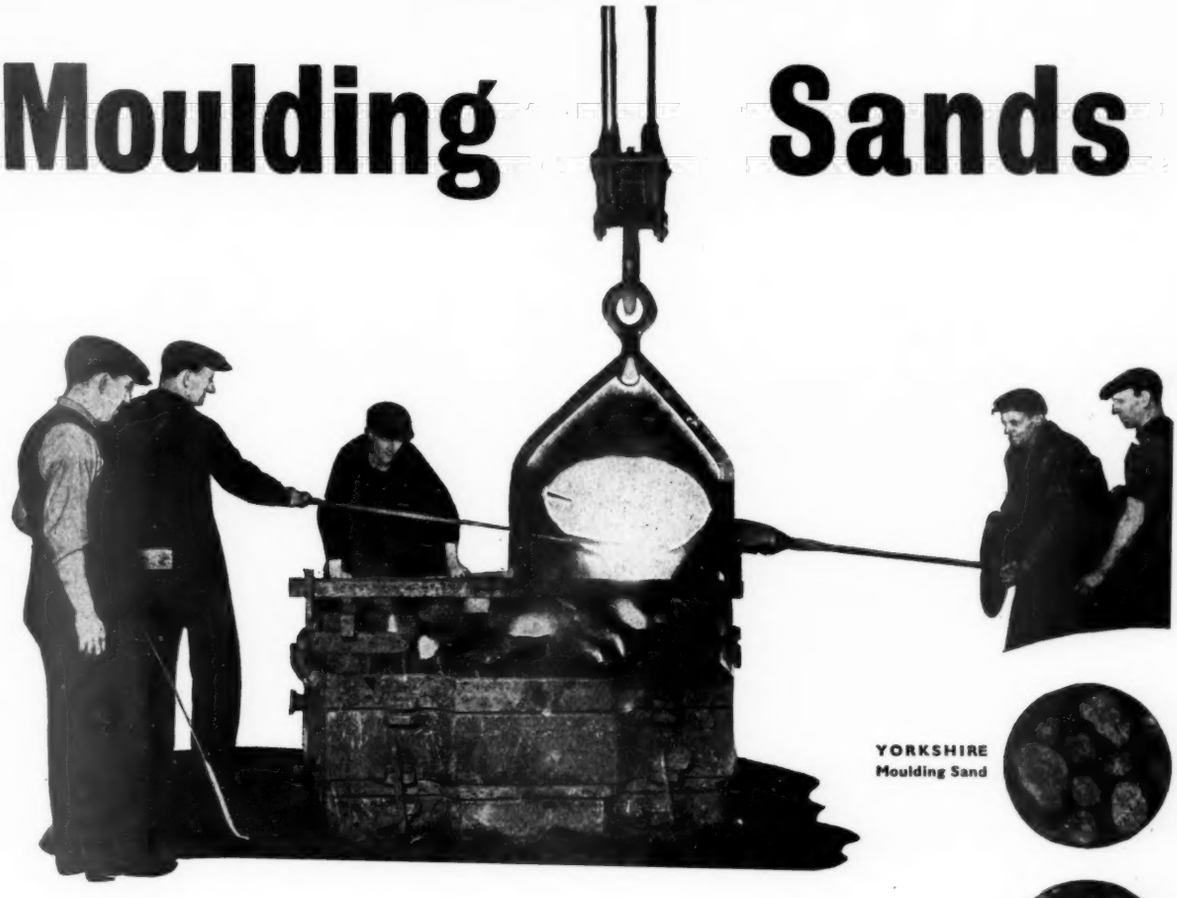
Institute of Metals (Birmingham Section):—"Synthetic Bearings for Mills," Paper by C. D. Phillippe, at James Watt Memorial Institute, Charles Henry Street, Birmingham, at 7 p.m.

Institute of Vitreous Enamellers

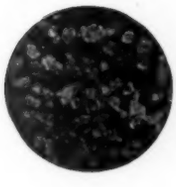
NOVEMBER 30.

Annual General Meeting:—At Midland Hotel, Birmingham, at 2 p.m., preceeded by informal luncheon at 12.45 p.m.

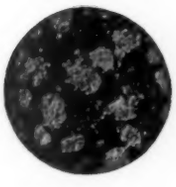
Moulding Sands



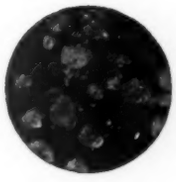
YORKSHIRE
Moulding Sand



THANET
Moulding Sand



YORK YELLOW
Moulding Sand



ZENITH
Moulding Sand

MANSFIELD
Moulding Sand

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Raw Material Markets

The controlled distribution of iron and steel is resulting in satisfactory deliveries being made to consumers in urgent need of supplies, while reports indicate that other users are also receiving reasonable consideration. With outputs running at record levels, the Ministry of Supply is now in a position to review the export market and in view of the importance of this to the national war effort shipments will be made as freely as possible. The Ministry is naturally keen to expand foreign credits and the substantial requirements of foreign users of iron and steel will do much to further this aim. Exports can, of course, only be made with the sanction of the Government, but licences will be granted if supplies can be spared.

Pig-Iron

MIDDLESBROUGH—General satisfaction is felt in this district at the working of the licensing system, whereby all consumers must obtain official permission before procuring supplies of iron. The scheme ensures that consumers do not hoard material and that buyers do not obtain iron in excess of their immediate requirements. Naturally, many users would welcome the opportunity to purchase more iron than many of them are at present allowed, but it is appreciated that the system is fair to all consumers. In addition, the information which has to be passed to the Ministry of Supply by consumers regarding existing stocks and potential requirements is of considerable advantage to the Government in assessing the total needs of industry and the amount likely to become available to meet the pressing needs of overseas buyers. The regular production of Cleveland foundry iron continues to be suspended, but it would appear likely that a revision of this position may shortly be made, as the larger consumers are compelled to seek elsewhere to satisfy their needs, thus imposing undue strain on the transport facilities at a time when these are already being used to good purpose. There is a reserve of furnaces which might be used for this purpose, but most of the furnaces at present working are fully engaged on the production of steel-making iron. In view of the active state of trade, business in hematite is largely of a hand-to-mouth character. The steel plants, of course, continue to be in the market for heavy tonnages, but there is a substantial inquiry from other users. Thus, makers' stocks have recently been drawn on freely.

LANCASHIRE—There is a satisfactory amount of work on hand at most heavy and light foundries, although more orders would be welcomed by most light-castings makers. Deliveries of pig-iron to consumers have been satisfactory on the whole and the revised system of licensing is generally considered to be a wise precaution on the part of the Government in so far as it should tend to preclude buyers from purchasing in excess of their actual requirements. The hematite market is firm.

MIDLANDS—A feature of the licensing system is that it will obviate the position of certain consumers being without supplies of iron when others are able to secure material to put into stock. All users must now first draw on their reserves before they are able to obtain further supplies. Local ironfoundries continue to work at a high rate of capacity. Despite recent Government orders, the light-castings trade is still rather poorly employed, although makers are undoubtedly better placed than they were a few weeks ago. Supplies of high-phosphorus iron are now forthcoming a little more freely. The position regarding low-phosphorus iron is still unsatisfactory, but larger tonnages are expected to become available in the near future. Hematite is obtainable without delay, but stocks are lower than they were before the war.

SCOTLAND—The output of 14 blast furnaces in this area is fully taken up. Light-castings founders are in a position to accept new business, but heavy founders are fully employed. No. 3 foundry iron is now quoted at 109s. 6d., f.o.t. furnaces. The demand for steel-making iron appears to be insatiable, but deliveries are despatched on a good scale.

Coke

Business in foundry coke is largely confined to contract deliveries, as most consumers have covered their needs up to the end of the year. The price uncertainty still exists, the current quotation being 50s. 6d. per ton for best Durham coke, delivered Birmingham and Black Country stations. In view of the recent increase in the price of blast-furnace coke it is possible that foundry-coke prices will also be moved upwards.

Steel

There has been a gratifying response from the Dominions in reply to the British demand for steel, and shipments of semis are coming through quite freely. This is especially pleasing, as the home requirements are heavy, despite the fact that outputs are at record levels. Steelworks continue to operate to capacity, and notwithstanding the difficulties of wartime results are very satisfactory. Consumers, on the whole, are being well catered for, and immediate requirements are generally being met. Users are naturally keen to cover ahead, but this presents certain difficulties, as works are unable to specify delivery dates with any degree of certainty.

Scrap

As anticipated, new schedules of prices for iron and steel scrap have now been introduced, and came into operation on Friday last. Full details appear elsewhere in this issue. The demand for scrap continues to be heavy, but reports indicate that deliveries are being made to consumers more freely as a result of the national scrap collection campaign, which is now in full swing. Nevertheless, there are still certain difficulties to be overcome before the balance is struck between supply and demand.

Metals

There have been several complaints of late regarding the methods adopted by the Ministry of Supply in connection with the non-ferrous metal trade. Merchants and brokers allege that they are being pushed out gradually; when the Control was first instituted they were treated as principals in transactions, but now delivery orders, contracts and invoices are being made out in the names of the consumers. The middlemen claim that they are not receiving fair treatment and their expert services are being overlooked. Consumers are now having to solve themselves the numerous problems in connection with arranging deliveries from warehouses, and a considerable amount of congestion is reported to have resulted already. In some cases, consumers have to apply more than once at the warehouses for their supplies of metal. The Ministry, it is alleged, are frequently causing an unreasonably large number of delivery orders to be on hand at one wharf at a time. Representations have been made to the Ministry, which, it is hoped, will give to the matter the sympathetic consideration which it has to other problems relating to the metal trade since the outbreak of the war.

Copper—Both France and Britain have made arrangements for the supply of copper during the war, and it would appear that the Allies are assured of a satisfactory supply. France has negotiated with American producers for the supply of 150,000 tons of copper for delivery over six months, and this is understood to be the commencement of an arrangement which is to be for the duration of hostilities. The price of 12.50 cents, f.a.s. New York, will be subject to revision quarterly. The British Government, too, has negotiated with producers to ensure that her requirements will be met in full. The copper production of Rhodesia is to be expanded from 237,000 tons in 1938 to around 300,000 annually, while the Union Minière du Haut Katanga, the Belgian Congo mining concern, is enlarging its copper refineries. This concern formerly supplied Germany with about 40,000 tons of copper a year, but this market has now been lost. The extent of the copper reserves of the enemy must remain an unknown quantity. They are variously estimated at up to the figure of 400,000 tons, but it is more generally believed that German stocks would be fairly quickly used up in the prosecution of a long war and her difficulties in obtaining replenishments are many. Yugoslavia, which could supply her with large tonnages, would no doubt demand c.o.d. terms, which the Reich Government might find to be embarrassing, while the problems involved in the transport of copper ore from the Soviet Union, too, would be hard to overcome. Under the agreement whereby Russia has promised economic assistance to Germany in return for German machinery and other products, Russia is believed to be experiencing difficulty in obtaining her goods from the Reich, and she will no doubt grow weary of supporting her new-found ally when the prospects of eventual payment become even more remote.

Mr. Francis L. Gibbs, a deputy chairman of the Rhokana Corporation, Limited, speaking at the annual meeting of the company in London last week, said that during the year a total of 2,817,500 tons of ore was hoisted. Their production for the year was 50,810 tons of blister copper and 31,691 tons of electrolytic copper, making a total of 82,501 tons, compared with 76,275 tons last year. Production and sales of cobalt again showed an increase.

Tin—Trading in this metal on the London Exchange continues to be restricted by the small amount of tin available, and prices remain at £230 for all positions. When the effects of the increased quotas are more noticeable, the tin position of Great Britain should be quite satisfactory.

The October/November issue of the "Statistical Bulletin" of the International Tin Research and Development Council (Statistical Office, 21, Prinsessegracht, The Hague, price 1s.) states that world tin production in the third quarter amounted to 47,200 tons, against 28,200 tons in the second and 34,500 tons in the first quarter of this year. Exports of the signatory countries amounted to 40,221 tons in the third quarter of 1939, against a permissible export under the control scheme (at an increased quota of 120 per cent.) of 62,391 tons. World apparent tin consumption in the third quarter is estimated at 38,800 tons, against 39,500 tons in the second and 35,900 tons in the first quarter of this year. The visible supply decreased by 1,066 tons to 21,708 tons during the third quarter, the carry-over increased during that period by 2,212 tons to 8,253 tons, and the smelters' stocks showed a decrease of 1,116 tons to 9,437 tons. There was, consequently, a slight increase in the total stocks to 39,398 tons. During October the visible supply showed a sharp increase of 8,987 tons to 30,695 tons, but the carry-over decreased by 1,989 tons.

Spelter—On the whole, the home demand for this metal is being met satisfactorily, but there is a pressing demand from India which in present circumstances has to be allowed to be neglected and may result in a substantial loss, as Indian consumers will probably seek to obtain their needs in Canada and Australia.

Lead—The fact that Russia continues to be in the market for lead suggests that she will be unable to supply Germany with the metal. In the United Kingdom, users continue to take up large tonnages and deliveries generally are satisfactory, although metal is not to spare for stocking purposes. The supply of Empire lead is steadily improving.

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